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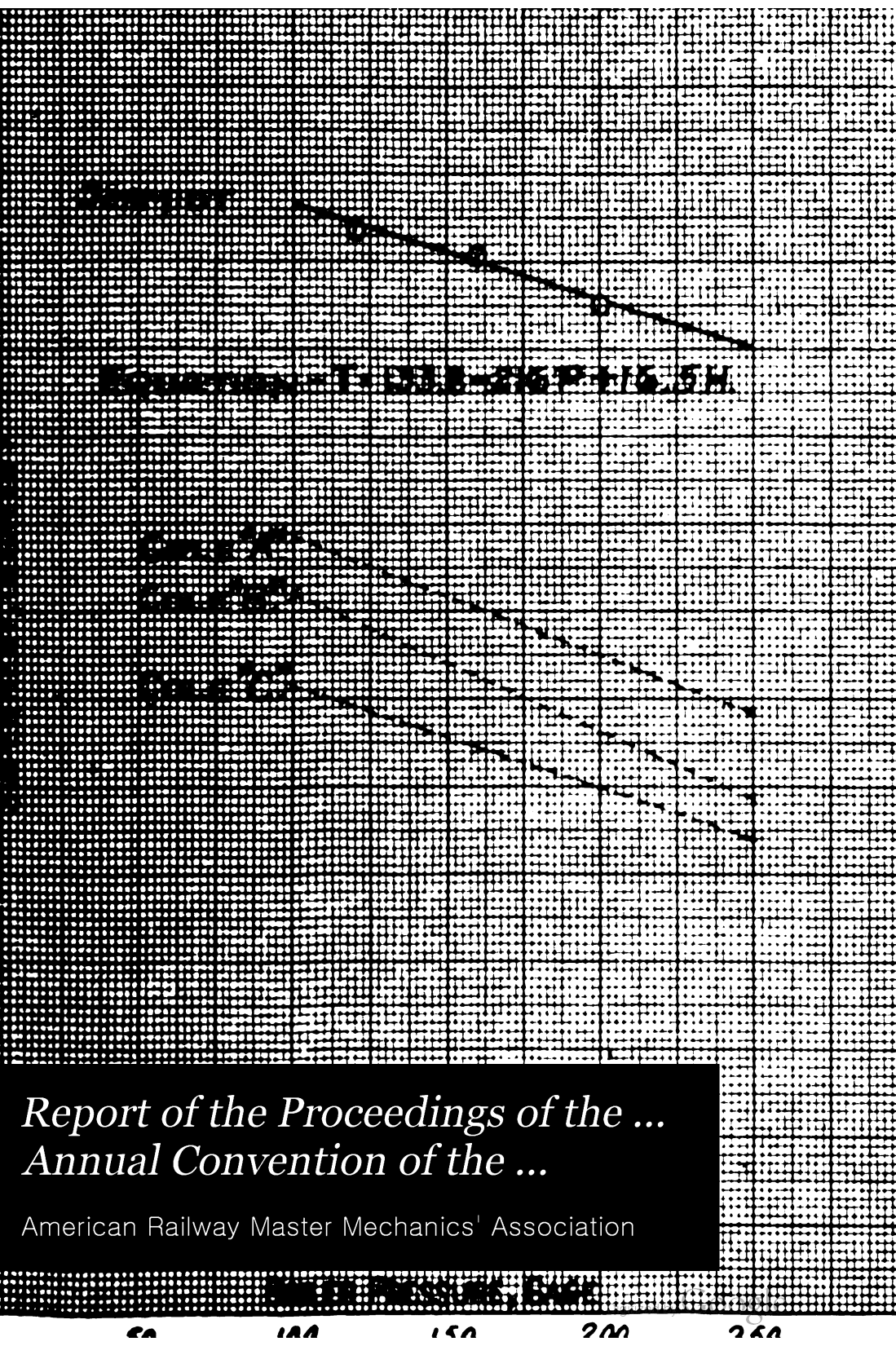
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Report of the Proceedings of the ... Annual Convention of the ...

American Railway Master Mechanics' Association



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REPORT OF THE PROCEEDINGS

OF THE

Forty-Fourth Annual Convention

OF THE

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION

(INCORPORATED)

HELD AT

ATLANTIC CITY, N. J.,

June 14, 15 and 16, 1911.

CHICAGO:
THE HENRY O. SHEPARD COMPANY
632 SHERMAN STREET
1911.

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OFFICERS FOR 1911-1912

ELECTED AT THE CLOSE OF CONVENTION OF 1911.

PRESIDENT.

H. T. BENTLEY, P. A. S. M. P., C. & N. W. Ry., Chicago, Ill.

FIRST VICE-PRESIDENT.

D. F. CRAWFORD, G. S. M. P., Penna. Lines, Pittsburgh, Pa.

SECOND VICE-PRESIDENT.

T. RUMNEY, G. M. S., Erie R. R., New York City.

THIRD VICE-PRESIDENT.

D. R. MACBAIN, S. M. P., L. S. & M. S. Ry., Cleveland, Ohio.

TREASURER.

ANGUS SINCLAIR, 114 Liberty street, New York City.

EXECUTIVE MEMBERS.

T. H. CURTIS, Peoples Gas Building, Chicago, Ill.
G. W. WILDIN, M. S., N. Y. N. H. & H. R. R., New Haven, Con.
F. F. GAINES, S. M. P., Cent. of Ga. Ry., Savannah, Ga.
C. A. SELEY, M. E., C. R. I. & P. Ry., Chicago, Ill.
J. F. WALSH, S. M. P., Ches. & Ohio Ry., Richmond, Va.
E. W. PRATT, A. S. M. P., C. & N. W. Ry., Chicago, Ill.

SECRETARY.

JOS. W. TAYLOR, 390 Old Colony Building, Chicago, Ill.

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COMMITTEES SELECTED FOR THE 1912 CONVENTION

STANDING COMMITTEES.

1. *Advisory Technical:*

G. W. WILDIN (Chairman), M. S., N. Y. N. H. & H. R. R., New Haven, Conn.
A. W. GIBBS, C. M. E., Penna. R. R., Philadelphia, Pa.
W. A. NETTLETON, G. S. M. P., C. R. I. & P. Ry., Chicago, Ill.

2. *Revision of Standards:*

T. W. DEMAREST (Chairman), S. M. P., Penna. Lines, Ft. Wayne, Ind.
J. D. HARRIS, Roland Park, Md.
W. E. DUNHAM, Supr. M. P. & M., C. & N. W. Ry., Winona, Minn.

3. *Mechanical Stokers:*

T. RUMNEY (Chairman), G. M. S., Erie R. R., New York City.
E. D. NELSON, Engr. Tests, Penna. R. R., Altoona, Pa.
C. E. GOSSETT, M. M., Minn. & St. Louis R. R., Minneapolis, Minn.
J. A. CARNEY, S. S., C. B. & Q. R. R., W. Burlington, Iowa.
T. O. SECHRIST, M. M., C. N. O. & T. P. Ry., Somerset, Ky.
S. K. DICKERSON, A. S. M. P., L. S. & M. S. Ry., Cleveland, Ohio.
GEO. HODGINS, 114 Liberty street, New York City.

SPECIAL COMMITTEES.

4. *Specifications for Cast-steel Locomotive Frames:*

C. B. YOUNG (Chairman), M. E., C. B. & Q. R. R., Chicago, Ill.
E. W. PRATT, A. S. M. P., C. & N. W. Ry., Chicago, Ill.
R. K. READING, S. M. P., Penna. R. R., Buffalo, N. Y.
O. C. CROMWELL, M. E., Balto. & Ohio R. R., Baltimore, Md.
C. E. FULLER, A. G. M., Union Pacific R. R., Omaha, Neb.
L. R. POMEROY, J. G. White & Co., New York City.

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5. Main and Side Rods:

W. F. KIESEL, JR., A. M. E., Penna. R. R., Altoona, Pa.
H. BARTLETT, G. S. M. P., Boston & Maine R. R., Boston.
G. LANZA, Mass. Institute of Technology, Boston, Mass.
H. B. HUNT, care American Locomotive Co., Chicago, Ill.
W. E. DUNHAM, Supervisor M. P. & M., C. & N. W. Ry., Winona, Minn.

6. Consolidation:

D. F. CRAWFORD (Chairman), G. S. M. P., Penna. Lines, Pittsburgh, Pa.
H. H. VAUGHAN, Asst. to V. P., Can. Pac. Ry., Montreal, Can.
G. W. WILDIN, M. S., N. Y. N. H. & H. R. R., New Haven, Conn.

7. Safety Valves:

W. J. TOLLERTON (Chairman), A. G. S. M. P., C. R. I. & P. Ry., Chicago, Ill.
I. B. THOMAS, S. M. P., Penna. R. R., Williamsport, Pa.
W. D. ROBB, Supt. M. P., Grand Trunk Ry., Montreal, Can.
PROF. E. C. SCHMIDT, Univ. of Illinois, Urbana, Ill.

8. Safety Appliances:

H. T. BENTLEY, P. A. S. M. P., C. & N. W. Ry., Chicago, Ill.
M. K. BARNUM, G. S. M. P., Ill. Cent. R. R., Chicago, Ill.
C. B. YOUNG, M. E., C. B. & Q. R. R., Chicago, Ill.

9. Design, Construction and Maintenance of Locomotive Boilers:

D. R. MACBAIN, S. M. P., L. S. & M. S. Ry., Cleveland, Ohio.
C. E. CHAMBERS, S. M. P., C. R. R. of N. J., Jersey City, N. J.
T. W. DEMAREST, S. M. P., Penna. Lines West, Ft. Wayne, Ind.
F. H. CLARK, G. S. M. P., B. & O. R. R., Baltimore, Md.
R. E. SMITH, G. S. M. P., A. C. L. R. R., Wilmington, N. C.
E. W. PRATT, A. S. M. P., C. & N. W. Ry., Chicago, Ill.
J. SNOWDEN BELL, 149 Broadway, New York City.

10. Contour of Tires:

W. C. A. HENRY (Chairman), S. M. P., Penna. Lines, Columbus, Ohio.
J. A. PILCHER, M. E., N. & W. Ry., Roanoke, Va.
O. C. CROMWELL, M. E., Balto. & Ohio R. R., Baltimore, Md.
H. C. OVIATT, M. M., N. Y. N. H. & H. R. R., E. Hartford, Conn.
O. M. FOSTER, M. M., L. S. & M. S. Ry, Elkhart, Ind.
G. W. SEIDEL, S. S., C. R. I. & P. R. R., Silvis, Ill.

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11. Steel Tires:

L. R. JOHNSON (Chairman), A. S. M. P., Can. Pac. Ry., Montreal, Can.
J. R. ONDERDONK, Engr. Tests, Balto. & Ohio R. R., Baltimore, Md.
C. H. HOGAN, D. S. M. P., N. Y. C. & H. R. R. R., Depew, N. Y.
R. L. ETTENGER, C. M. E., Southern Ry., Washington, D. C.
L. H. TURNER, S. M. P., P. & L. E. R. R., Pittsburgh, Pa.

12. Flange Lubrication:

M. H. HAIG (Chairman), M. E., A. T. & S. F. Ry., Topeka, Kan.
T. W. HEINTZLEMAN, S. M. P., So. Pac. Co., Sacramento, Cal.
D. J. REDDING, M. M., P. & L. E. R. R., McKees Rocks, Pa.
A. KEARNEY, A. S. M. P., N. & W. R. R., Roanoke, Va.
W. C. HAYES, S. L. O., Erie R. R., New York City.

13. Minimum Requirements for Headlights:

D. F. CRAWFORD (Chairman), G. S. M. P., Penna. Lines, Pittsburgh, Pa.
A. R. AYERS, A. M. M., L. S. & M. S. Ry., Elkhart, Ind.
C. H. RAE, G. M. M., L. & N. R. R., Louisville, Ky.
J. W. SMALL, S. M., Mo. Pacific Ry., St. Louis, Mo.
F. A. TORREY, G. S. M. P., C. B. & Q. Ry., Chicago, Ill.

14. Standardization of Tinware:

A. J. POOLE, S. M. P., Seaboard Air Line Ry., Portsmouth, Va.
M. D. FRANEY, A. M. M., L. S. & M. S. Ry., Collinwood, Ohio.
J. C. MENGEL, M. M., Penna. R. R., Altoona, Pa.

15. Maintenance of Superheater Locomotives:

R. D. SMITH, S. M. P., Boston & Albany R. R., Boston, Mass.
W. H. BRADLEY, M. M., C. & N. W. Ry., Clinton, Iowa.
H. H. VAUGHAN, Asst. to V. P., Can. Pac. Ry., Montreal, Can.
JAS. CHIDLEY, M. M., L. S. & M. S. Ry., Collinwood, Ohio.
J. B. KILPATRICK, S. M. P., C. R. I. & P. Ry., Davenport, Iowa.

16. Arrangements:

H. T. BENTLEY, P. A. S. M. P., C. & N. W. Ry., Chicago, Ill.

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CONSTITUTION AND BY-LAWS.

ARTICLE I.

NAME.

The name of this Association shall be the "American Railway Master Mechanics' Association."

ARTICLE II.

OBJECTS OF ASSOCIATION.

The objects of this Association shall be the advancement of knowledge concerning the principles, construction, repair and service of the rolling stock of railroads, by discussions in common, the exchange of information, and investigations and reports of the experience of its members; and to provide an organization through which the members may agree upon such joint action as may be required to give the greatest efficiency to the equipment of railroads which is intrusted to their care.

Subjects involving legal, transportation, permanent way or traffic questions, or for any other reason requiring such action, may be submitted as recommendations to the American Railway Association.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The following persons may become active members of the Association on being recommended by two members in good standing, signing an application for membership and agreement to conform to the requirements of the Constitution and By-Laws, or authorizing the Secretary to sign the Constitution for them:

(1) Those above the rank of general foreman, having charge of the design, construction or repair of railway rolling stock.

(2) General foremen, if their names are presented by their superior officers.

(3) Two representatives from each locomotive and car building works.

(4) One representative member may be appointed by any railroad company to represent its interests in the Association. Such appointment shall be in writing and shall emanate from the President, General Manager or General Superintendent. Such member shall have all the privileges of an active member, including one vote on all questions, and, in addition thereto, shall, on all measures pertaining to the determination of what tests shall be conducted by the Association or the expenditure of money for conducting same, have one additional vote for each full one hundred

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engines which are in actual operatior or in process of purchase by the road or system which he represents. Such membership shall continue until notice is given the Association of his withdrawal or the appointment of his successor.

SEC. 2. Civil and mechanical engineers, or other persons having such a knowledge of science or practical experience in matters pertaining to the construction of rolling stock as would be of special value to the Association or railroad companies, may become associate members on being recommended by three active members. The name of such candidate shall then be referred to a committee, to be appointed by the President, which shall investigate the fitness of the candidate, and report to the Executive Committee of the Association at the next annual meeting. If the report be unanimous in favor of the candidate the name shall be submitted to letter ballot, and five dissenting votes shall reject. The number of associate members shall not exceed twenty, and they shall be entitled to all the privileges of active members, excepting that of voting.

SEC. 3. (1) All members of the Association, excepting as hereafter provided, shall be subject to the payment of such annual dues as it may be necessary to assess for the purpose of defraying the expenses of the Association, provided that no assessment shall exceed $5 a year.

(2) A representative member shall pay in addition to his personal dues as above, an amount for each additional vote to which he is entitled, as shall be determined each year by the Executive Committee, prorated upon the cost of conducting such tests as may be determined upon at each convention, provided that no such assessment shall exceed $5 per vote per year.

Such dues shall be payable when the amount thereof is announced by the President, at each annual meeting. Any member who shall be two years in arrears for annual dues, shall be notified of the fact, and if the arrears are not paid within three months after such notification, his name shall be taken from the roll and he be duly notified of the same by the Secretary.

SEC. 4. Any person who has been or may be duly qualified as a member of this Association will remain such until his resignation is voluntarily tendered, or he becomes disqualified by the terms of the Constitution. Members whose names have been dropped for non-payment of dues may be restored to membership by the unanimous consent of the Executive Committee on the payment of all back dues.

SEC. 5. Members of the Association, active or associate, who have been in good standing for not less than five years, and who through age or other cause cease to be actively engaged in the mechanical department of railway service, may, upon the unanimous vote of the members present at the annual meeting, be elected honorary members. The nominations must be made by the Executive Committee. The dues of the honorary members shall be remitted, and they shall have all the privileges of active members except that of voting.

SEC. 6. Any member who, during the meetings of the Association,

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shall be guilty of dishonorable conduct which is disgraceful to a railroad officer and a member of the Association, or shall refuse to obey the chairman when called to order, may be expelled by a two-thirds affirmative vote at any regular meeting of the Association held within one year from the date of the offense.

ARTICLE IV.

OFFICERS.

SECTION 1. The officers of the Association shall be a President, a First Vice-President, a Second Vice-President, a Third Vice-President, a Treasurer, a Secretary, and six Executive members, the six Executive members with the President, Vice-Presidents and Treasurer shall constitute the Executive Committee, and they, with the exception of the Secretary, shall constitute the Executive Committee of the Association.

ARTICLE V.

DUTIES OF OFFICERS.

SECTION 1. It shall be the duty of the President to preside at all the meetings of the Association, appoint all committees — designating the chairman — except as hereinafter provided, and approve all bills against the Association for payment by the Treasurer.

SEC. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the Association.

SEC. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore*.

SEC. 4. It shall be the duty of the Secretary to keep a full and correct record of all transactions at the meetings of the Association; to keep a record of the names and places of residence of all members, and the name of the railway they each represent; to certify to the persons who are eligible as candidates for the Association's scholarships at the Stevens Institute of Technology; to receive and keep an account of all money paid to the Association and deliver the same to the Treasurer, taking his receipt for the amount; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the Association; to receive all bills and pay the same, after having approval of the President; to deliver all bills paid to the Secretary at the close of each meeting, taking a receipted statement of the same and to keep an accurate book account of all transactions pertaining to his office.

ARTICLE VI.

EXECUTIVE COMMITTEE.

SECTION 1. The Executive Committee shall exercise a general supervision over the interests and affairs of the Association, recommend the

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amount of the annual assessment, to call, to prepare for, and to conduct general conventions, and to make all necessary purchases, expenditures and contracts required to conduct the current business of the Association, but shall have no power to make the Association liable for any debt to an amount beyond that which at the time of contracting the same shall be in the Treasurer's hands in cash, but not subject to prior liabilities. All expenditures for special purposes shall only be made by appropriations acted upon by the Association at a regular meeting.

SEC. 2. The Executive Committee shall receive, examine and approve before public reading, all communications, papers and reports on all mechanical and scientific matters; they shall decide what portion of the reports, papers and drawings shall be submitted to each convention and what portion shall be printed in the annual report. It shall also determine which, if any, of the subjects presented at the convention, or by the members, shall be referred to the American Railway Association.

SEC. 3. Five members of the Executive Committee shall constitute a quorum for the transaction of business.

SEC. 4. The Executive Committee shall form with a committee of the Master Car Builders' Association a Joint Committee to decide on the place of meeting for the annual convention.

ARTICLE VII.

ASSOCIATION SCHOLARSHIPS.

It shall be the duty of the Secretary to issue a circular annually, intimating the date and place when and where candidates may be examined for the scholarships of the Association in the Stevens Institute of Technology, Hoboken, New Jersey.

Acceptable candidates for the scholarship shall be, first, sons of members or of deceased members of the Association. If there is not a sufficient number of such applicants for the June examination, then applications will be received from other railroad employes or the sons of other railroad employes for the fall examination. The Secretary shall issue a proper circular in this case as before. In extending the privilege outside of the families of members, preference shall be given to employes or the sons of employes, or the sons of deceased employes of the mechanical departments.

Candidates for these scholarships shall apply to the Secretary of this Association, and if found eligible shall be given a certificate to that effect for presentation to the school authorities. This will entitle the candidate to attend the preliminary examination. If more than one candidate passes the preliminary examination, the applicant passing the highest examination shall be entitled to the scholarship, the school authorities settling the question.

The successful candidate shall be required to take the course of mechanical engineering.

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ARTICLE VIII.

ELECTION OF OFFICERS.

SECTION 1. The officers of the Association, except the Secretary as hereinafter provided, shall be elected by ballot separately without nomination at the regular meeting of the Association, held in June of each year. A majority of all votes cast shall be necessary to an election, and elections shall not be postponed. The President, Vice-Presidents and Treasurer shall hold office for one year, and Executive members for two years, or until successors are chosen, provided, however, that three Executive members shall be elected for one year at the time of the adoption of this amendment. Three Executive members shall be elected each year thereafter.

SEC. 2. Two tellers shall be appointed by the President to conduct the election and report the results.

SEC. 3. A Secretary from among the members of the Association shall be appointed by a majority of the Executive Committee at its first meeting after the annual election, or as soon thereafter as the votes of a majority of the members of the Executive Committee can be secured for a candidate. The term of office of the Secretary thus appointed, unless terminated sooner, shall cease at the first meeting, after the next annual election succeeding his appointment, of the Executive Committee organized for the transaction of business. Two-thirds of the members of the Executive Committee shall have power to remove the Secretary at any time. His compensation, if any, shall be fixed for the time that he holds office by vote of the majority of the Executive Committee. He shall also act as Secretary of the Executive Committee.

ARTICLE IX.

AUDITING COMMITTEE.

SECTION 1. At the first session of the annual meeting an Auditing Committee, consisting of three members not officers of the Association, to be nominated by any member who does not hold office, shall be elected in the same way as officers are voted for. This Auditing Committee shall examine the accounts and vouchers of the Treasurer and certify whether they have been found correct or not. After the performance of this duty they shall be discharged by the acceptance of their report by the Association.

COMMITTEE ON SUBJECTS FOR INVESTIGATION AND DISCUSSION.

SEC. 2. At each annual meeting the President shall appoint a commitee whose duty it shall be to report at the next annual meeting subjects for investigation and discussion, and if the subjects are approved by the Association the President, as hereinafter provided, shall appoint committees to report on them. It shall also be the duty of the committee to receive from members questions for discussion during the time set apart for that purpose. This committee shall determine whether such questions are

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suitable ones for discussion, and if so, they shall so report them to the Association.

COMMITTEES ON INVESTIGATION.

SEC. 3. When the Committee on Subjects has reported, and the Association approved of subjects for investigation, the President shall appoint individuals or special committees to investigate and report on them, and may authorize and appoint a *special* committee to investigate and report on any subject which a majority of the members present may approve; or individual papers may be presented to the Association after approval by the Executive Committee. Papers and reports shall be presented by abstracts, which shall not occupy more than ten minutes in the reading unless otherwise ordered by the Association.

RECOMMENDATIONS OF STANDARDS.

SEC. 4. Any proposition recommending the adoption of standard construction or practice shall be in writing and be accompanied by drawings, if the latter are necessary for a clear understanding of the subject. Such proposition shall then be submitted to the Association for discussion, after which a vote shall be taken to decide whether the proposition shall be submitted for decision by letter ballot to all the members entitled to vote. If decided in the affirmative, the Secretary, within three months from the time the vote of the Association is taken on such measure, shall send by mail to each member a blank ballot, and a copy of the proposed recommendation, with a report, to be approved by the Executive Committee, of the discussion thereon; such ballot to be filled up, signed and remailed to the Secretary, who will count all the ballots received within thirty days from the date they were sent to the members, and he shall then announce the vote in such manner as the Executive Committee may prescribe. Any recommendation securing two-thirds of the votes cast shall be adopted by the Association.

SEC. 5. All reports, resolutions and recommendations involving the use, or proposed use, by railroad companies, of any device or process which forms the subject matter of any existing patent, shall first be submitted to the Executive Committee, and shall be submitted to the Association only by the Executive Committee.

ARTICLE X.

AMENDMENTS.

SECTION 1. The Constitution may be amended at any regular meeting by a two-thirds vote of the members present, provided that written notice of the proposed amendments has been given at a previous meeting at least six months before.

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BY-LAWS.

TIME OF MEETING.

I. The regular meeting of the Association shall be held annually in June of each year.

HOURS OF SESSION.

II. The regular hours of session shall be from 9:30 o'clock A.M. to 1:30 o'clock P.M.

PLACE OF MEETING.

III. The time and place for holding the Annual Convention shall be selected by a Joint Committee composed of the President, three Vice-Presidents and Treasurer of this Association and a corresponding committee from the Master Car Builders' Association. This Joint Committee shall meet within six months after the convention and decide upon the time and place of meeting.

QUORUM.

IV. At any regular meeting of the Association, fifteen or more members entitled to vote shall constitute a quorum.

ORDER OF BUSINESS.

V. The business of the meetings of this Association shall, unless otherwise ordered by a vote, proceed in the following order:

1. Opening prayer.
2. Address by the President.
3. Acting on the minutes of the last meeting.
4. Reports of Secretary and Treasurer.
5. Assessment and announcement of annual dues.
6. Election of Auditing Committee.
7. Unfinished business.
8. New business.
9. Reports of committees.
10. Reading of papers and discussion of questions propounded by members.

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11. Routine and miscellaneous business.
12. Election of officers.
13. Adjournment.

QUESTIONS FOR DISCUSSION, SPECIAL ORDER OF.

VI. Unless otherwise ordered, the discussion of questions proposed by members shall be the special order from 12 o'clock M. to 1 P.M. of each day of the annual meeting.

DECISIONS.

VII. The votes of a majority of the members shall be required to decide any question, motion or resolution which shall come before the Association, unless otherwise provided.

DISCUSSIONS.

VIII. No patentees or their agents shall be admitted in the meetings of the Association for the purpose of advocating the claims of any patent or patentee, unless by unanimous consent.

IX. No member shall speak more than twice in the discussion of any question until all the other members who want to speak, and have not been heard, have spoken, and no member shall have the floor more than five minutes at a time unless otherwise ordered.

X. The reports of all standing and special committees must be in the office of the Secretary not later than April 1, in order that the same can be printed and advance copies issued by May 1.

XI. Committee reports which do not reach the Secretary in time for printing and issuing by May 1 will be referred to the Executive Committee to decide whether the report shall be submitted to the convention.

XII. The chairman of a standing or special committee will read an abstract of the report of the committee before the convention, together with whatever additional data may have been accumulated after April 1, to the date of the convention.

XIII. The members of standing and special committees who may individually or collectively submit a minority report, must prepare the same so that it can be issued with the report of the majority of the committee and substituted for the majority report in the event the convention should so decide.

XVI. Each member of a standing or special committee must sign either the majority or the minority report.

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NAMES AND ADDRESSES OF MEMBERS.

Active members are shown in Roman letters; representative members in italics.

ACTIVE MEMBERS.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1905	Adams, A. B		G. F., Gulf, Colo. & Santa Fe	Temple, Tex.
1903	Adams, A. C		S. M. P., Spokane, Portland & Seattle Ry.	Portland, Ore.
1896	Adams, T. E		G. M. M., St. Louis Southwestern	Pine Bluff, Ark.
1888	Addis, J. W		S. M., P. & R. S., Texas & Pacific	Marshall, Tex.
1895	Aiken, C. L		Boston & Maine	South Lawrence, Mass.
1907	Akans, Geo		M. M., Southern	Birmingham, Ala.
1906	Albright, J. S		M. M., Mexican Interoceanic	Puebla, Mex.
1887	Aldcorn, Thos		Chicago Pneumatic Tool Co	95 Liberty st., N. Y. City.
1902	Aldana, H. Lopez		S. M. P., Central Northern	Tucuman, Arg. Rep., S. A.
1909	Allan, Arthur		M. M., Temiskaming & No. Ontario	North Bay, Ont., Can.
1906	Allen, C. E		M. M., Northern Pacific	Livingston, Mont.
1906	Allen, C. W			Reading, Pa.
1911	Alling, E. W		M. M., N. Y. C. & H. R. R. R	Taunton, Mass.
1908	Allison, W. L		W. S. M., Franklin Ry. Supply Co	Chicago, Ill.
1907	Allport, J. S		G. F., Copper Range	Houghton, Mich.
1904	Allport, Wm		M. M., Zuni Mountain	Ketner, N. M.
1895	Amann, W. E		Galena Signal Oil Co	520 Rialto Building, San Francisco, Cal.
1909	Anthony, F. S		S. M., Texas & Pacific Ry	Marshall, Tex.
1892	Ants, Oscar			Care of The Wright, Dunkirk, N. Y
1906	Appler, A. B		M. E., Delaware & Hudson Co	Green Island, N. Y.
1911	Arden, D. D		M. M., Savannah & Statesboro Ry	Statesboro, Ga.
1887	*Arp, W. C*		*S. M. P., Vandalia*	*Terre Haute, Ind.*
1910	Arthur, C. G		M. M., So. Ry	Columbia, S. C.
1903	Ashton, Harry			401 Delaware ave., Toronto, Ont., Can.
1901	Ashworth, Jas		M. M., Louisville & Nashville	Birmingham, Ala.
1905	Asselin, George		P. E. M. P., Northern Ry. of France	Paris, France.
1890	Atkinson, R			Philadelphia, Pa.
1896	Atterbury, W. W		V. P., Pennsylvania	Philadelphia, Pa.
1887	Augustus, W		M. M., Chicago, Burlington & Quincy	Centerville, Iowa.
1886	Austin, W. L		Baldwin Locomotive Works	Philadelphia, Pa.
1907	Ayers, A. R		M. E., L. S. & M. S	Cleveland, Ohio.
1903	Ayers, H. B			Care of H. B. Porter & Co., Pittsburgh, Pa.
1896	Babcock, C. M		M. M., Texas & Pacific	New Orleans, La.
1898	Baker, C. F		Hudson Companies	100 Broadway, N. Y.
1902	Baker, P. G		M. M., Panama	Colon, Colombia, S. A.
1905	Balderston, J. W			218 South Chicago st., Los Angeles, Cal.
1901	Ball, H. F		V. P., American Loco. Co	30 Church st., New York.
1910	Bannatyne, A. W		B. A. W. Ry	Liniers, Buenos Aires, Arg. Rep., S. A.
1905	Barclay, F. B		M. M., Illinois Central	McComb, Miss.
1906	Bardsley, A			
1890	Barnum, M. K		G. S. M. P., Ill. Cent. R. R	Chicago, Ill.
1895	*Bartlett, Henry*	1060	*G. S. M. P., Boston & Maine*	*Boston, Mass.*

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JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1904	Barton, T. F.		M. M., Dela., Lack. & Western	Kingsland, N. J.
1909	Bawden, Wm.		M. M., Terminal R. R. Assn.	St. Louis, Mo.
1909	Bayley, J. J.		M. M., Southern	Lawrenceville, Va.
1908	Beamer, James A.		M. M., Pennsylvania	Tyrone, Pa.
1889	Bean, S. L.		M. S., Santa Fe Lines	Los Angeles, Cal.
1892	Beattie, A. L.		S. M. P., New Zealand Government	Wellington, N. Z.
1899	Beauclerk, T. S.		Central Argentino	Rosario de Santa Fe, Arg. Rep., S. A.
1894	Beaumont, J. G.		Southern Railways of Peru	Arequipa, Peru.
1892	Bechhold, H. G.		Cleveland Frog & Crossing Co.	Cleveland, Ohio.
1911	Bedell, W. A.		M. M., Mo. Pac. Ry.	Van Buren, Ark.
1910	Bell, R. W.		S. M., Ill. Cent. R. R.	Chicago, Ill.
1905	Bennett, Geo. R.		G. F., Mobile & Ohio	Whistler, Ala.
1910	Bennett, W. H.		M. M., Penna. R. R.	Juniata, Pa.
1903	Bennett, W. J.		A. S. M. P., Chgo., Indpls. & Louisville	La Fayette, Ind.
1900	Bentley, H. T.		P. A. S. M. P. & M., Chicago & North West.	Chicago, Ill.
1906	Bentley, L. L.		M. E., Armstrong Cork Co.	Beaver Falls, Pa.
1902	Berry, A. O.		S. S., L. S. & M. S. Ry.	Elkhart, Ind.
1900	Best, W. N.			11 Broadway, New York.
1903	Billingham, R. A.		G. M. M., Pitts., Shawmut & Northern	St. Marys, Pa.
1902	Bingaman, Chas. A.		Eng. of Tests, Phila. & Reading	Reading, Pa.
1911	Bingley, W. J.		M. M., Western Maryland R. R.	Hagerstown, Md.
1910	Bishop, G. C.		S. M. P., Long Island R. R.	Richmond Hill, L. I.
1899	Bissett, J. R.		M. M., Seaboard Air Line	Raleigh, N. C.
1909	Black, W. G.		M. M., N. Y., Chgo. & St. Louis	(Stony Island) Chicago, Ill.
1901	Blake, R. P.			119 No. Yellowstone st., Livingston, Mont.
1909	Blunt, Jas. G.		Supt., Gen'l Drawing Room, Amer. Loco. Co.	Schenectady, N. Y.
1904	Bock, M. G.		S. M. P. & R. S., De Queen & Eastern	De Queen, Ark.
1899	Boldridge, R. M.		M. M., Central of Georgia	Cedartown, Ga.
1910	Booth, J. K.		G. F., B. & L. E. R. R.	Greenville, Pa.
1904	Booth, J. S.		M. M., Carolina & Northwestern	Chester, S. C.
1904	Booth, Thos.		M. S., Pecos Valley Lines	Amarillo, Tex.
1909	Boughton, Wm.		G. M. M., Pere Marquette R. R.	Detroit, Mich.
1909	Bowden, J. F.		M. M., Baltimore & Ohio	Garrett, Ind.
1897	Bowles, C. K.		M. M., Tidewater & Western	Chester, Va.
1907	Boyden, N. N.		M. M., Southern	Atlanta, Ga.
1895	Bradeen, J. O.		D. S. M. P., N. Y. Cent. & Hudson River	Oswego, N. Y.
1888	Bradley, W. F.		Supt., Ann Arbor	Toledo, Ohio.
1904	Brady, T. F.		S. M., Mapini	Mapini, Durango, Mex.
1894	Branch, Geo. E.			292 Prospect place, Brooklyn, N. Y.
1911	Brandt, C. A.		M. E., C. C. C. & St. L. Ry.	Indianapolis, Ind.
1896	Brangs, P. H.			11 Broadway, New York City.
1900	Brassell, J. K.		M. M., Cal. Northwestern	Tiburn, Cal.
1902	Brazier, F. W.		S. R. S., N. Y. Cent. & Hudson River	New York City.
1892	Brehm, W. H.		M. M., Mo., Kan. & Tex.	Parsons, Kan.
1904	Breneman, H. N.			135 N. Duke St., Lancaster, Pa.
1911	Brewer, J. W.		M. M., B. & O. R. R.	Baltimore, Md.
1909	Bridges, E. A.		M. M., Durham & Southern	Durham, N. C.
1879	Briggs, R. H.		M. M., St. Louis & San Francisco	Memphis, Tenn.
1898	*Bronner, E. D.*	479	*S. M. P., Michigan Central*	*Detroit, Mich.*
1887	Brooke, Geo. D.			2742 Bryant ave., Minneapolis, Minn.
1908	Brooks, E. G.		M. M., Mobile & Ohio	Whistler, Ala.
1905	Brown, H. B.		M. M., Erie	Cleveland, Ohio.
1911	Brown, H. M.		M. M., Ches. & Ohio Ry.	Hinton, W. Va.
1900	Brown, M. G.		M. M., Gulf & Ship Island R. R.	Gulfport, Miss.
1904	Brown, T. A.		S. M. P., Louisiana & Arkansas	Stamps, Ark.
1891	Brown, W. A.		M. M., Kanawha & Michigan	Middleport, Ohio.

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1897	Bruce, Geo. A.		G. M. M., Great Northern	St. Paul, Minn.
1890	Bruck, Henry T.		M. of M., Cumb. & Penna.	Mt. Savage, Md.
1906	Bryant, E. G.		D. M. M., International & Great North.	Mart, Tex.
1900	Buchanan, A., Jr.		Public Service Commission	Albany, N. Y.
1911	Bunker, W. D.		M. M., Colo. & Wyoming Ry.	Pueblo, Colo.
1906	Burel, W. C.			Walnut Ridge, Ark.
1905	Burgis, E. W.		M. M., N. O., Ft. Jackson & Grand Isle.	Algiers, La.
1909	Burk, C. H.		Loco. Supt., Mexican	Orizaba, V. C., Mex.
1910	Burley, J. M.		M. M., Pacific & Idaho Northern Ry.	Weiser, Idaho.
1910	Burns, Frank.		M. M., St. L. & S. F. R. R.	Monett, Mo.
1909	Burton, T. L.		Gen'l Insp., Cent. R. R. of N. J.	Jersey City, N. J.
1893	Bush, S. P.		G. M., Buckeye Steel Castings Co.	Columbus, Ohio.
1903	Bushmeyer, C. J.		R. H. F., Frisco Lines	Oklahoma City, Okla.
1906	Bussing, G. H.		S. M. P. & R. S., Evans. & Terre Haute.	Evansville, Ind.
1911	Butler, W. S.		M. M., Ches. & Ohio Ry.	Huntington, W. Va.
1904	Cameron, J. E.		M. M., K. G. & S. W. Ry.	Kentwood, La.
1903	Campbell, A. A.		M. M., Kansas City Southern	Shreveport, La.
1908	Campbell, S. J.		M. M., C. & A. R. R.	Slater, Mo.
1909	Canfield, J. B.		M. M., Boston & Albany	W. Springfield, Mass.
1910	Cantwell, J. L.		G. F., Southern Ry.	Princeton, Ind.
1902	Caracristi, V. Z.		C. E., D. & H. Co.	Albany, N. Y.
1904	Cargo, B. B.		M. M., Lake Terminal	Lorain, Ohio.
1900	Carney, J. A.		S. S., Chicago, Burlington & Quincy	West Burlington, Iowa.
1907	Carroll, J. T.		S. M. P., B. & O. R. R.	Pittsburgh, Pa.
1911	Carroll, W. P.		M. M., N. Y. C. Lines	Rochester, N. Y.
1903	Carson, F. L.		M. M., Mexican Central	Torreon, Coah., Mex.
1907	Carson, H. M.		G. S., Pennsylvania	Williamsport, Pa.
1889	Casanave, F. D.			1710 Market St., Philadelphia, Pa.
1890	Casey, J. J.		Supt., American Car & Foundry Co.	Jeffersonville, Ind.
1904	Cassidy, D. E.		A. M. M., Pennsylvania	Verona, Pa.
1892	Chamberlin, E.		N. Y. Central Lines	Grand Central Terminal, New York City.
1903	Chambers, C. E.		S. M. P., Central R. R. of N. J.	Jersey City, N. J.
1893	Chambers, John S.		S. M. P., Atlantic Coast Line	Rocky Mount, N. C.
1901	Chase, C. F.		Manchester Loco. Works	Manchester, N. H.
1909	Chenowith, E. G.		M. E., Erie	Meadville, Pa.
1904	Chester, W. E.			400 Central ave., Atlanta, Ga.
1905	Chidley, Joseph.		M. M., Lake Shore & Michigan Southern.	Collinwood, Ohio.
1906	Chisholm, J. E.		First National Bank Building	Chicago, Ill.
1898	Christopher, J.		M. M., Toronto, Hamilton & Buffalo.	Hamilton, Ont., Can.
1908	Chrysler, W. P.		A. S. M. P., Chgo. Great Western	Oelwein, Iowa.
1902	Churchward, G. J.		Great Western	Swindon, England.
1905	Clark, David			Los Angeles, Cal.
1899	*Clark, F. H.*		*G. S. M. P., Balt. & Ohio*	*Baltimore, Md.*
1903	Clark, J. H.		M. M., Staten Island R. T.	Clifton, S. I., New York.
1897	Clarke, Owen.		M. M., Texas & Pacific	Marshall, Tex.
1903	Clarkson, W. S.			New Haven, Conn.
1893	Cleaver, F. C.		S. M. P., Rutland	Rutland, Vt.
1910	Cleland, M. E.		D. F., Philippine Ry.	Cebu, Island of Cebu, P. I.
1877	Clifford, J. G.		M. M., Louisville & Nashville	10th and Kentucky sts., Louisville, Ky.
1887	Cloud, John W.			82 York Road, King's Cross, London, Eng.
1903	Cockfield, William.		Loco. Supt., Peruvian Southern	Arequipa, Peru.
1896	Cole, F. J.		C. C. E., American Locomotive Co.	Schenectady, N. Y.
1911	Cole, Jos.		M. M., Vera Cruz Terminal Co.	Vera Cruz, V. C., Mex

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1904	Cole, T. J.		M. M., Erie	Meadville, Pa.
1908	Cole, W. H.		M. M., United Verde & Pacific	Jerome, Ariz.
1909	Coleman, C.		M. M., Chicago & North Western	Winona, Minn.
1907	Collier, L. L.		D. F., A. T. & S. F. Ry.	Ashfork, Ariz.
1906	Collins, W. H.		M. M., Fonda, Johnstown & Gloversville	Gloversville, N. Y.
1911	Combs, W. B.		M. M., Macon, Dublin & Savannah Ry.	Macon, Ga.
1906	Conners, J. J.		M. M., Chicago, Milwaukee & St. Paul	Dubuque, Iowa.
1890	*Connolly, J. J.*	93	*S. M. P., Dul., So. Shore & Atlantic*	*Marquette, Mich.*
1879	Cook, John S.		M. M., Georgia	Augusta, Ga.
1908	Cook, T. R.		M. M., Penna. Lines	Wellsville, Ohio.
1904	Cooper, F. R.			1928 McCormick Bldg., Chicago, Ill.
1902	Cota, A. J.		M. M., Chicago, Burlington & Quincy	Chicago, Ill.
1908	Courtney, E. G.		M. M., Ark., La. & Gulf	Monroe, La.
1904	Coutant, M. R.		M. M., Ulster & Delaware	Rondout, N. Y.
1910	Cox, R. G.		M. M., Virginia & Southwestern Ry.	Bristol, Va.-Tenn.
1900	Crawford, D. F.		G. S. M. P., Pennsylvania Lines	Pittsburg, Pa.
1904	Cromwell, O. C.		Elsinor & Beech ave.	Baltimore, Md.
1902	Cross, C. W.		Supt. Apprentices, N. Y. Cent. Lines	New York City.
1910	Cross, J. W.		Supt., Springfield Ry. Co.	Crossburn, N. S., Can.
1893	*Cross, W.*	504	*Asst. to 2d V.-P., Canadian Pacific*	*Winnipeg, Man., Can.*
1911	Crownover, G. M.		M. M., Chicago Great Western Ry.	Oelwein, Iowa.
1908	Cullinan, John		M. M., Central Indiana	Muncie, Ind.
1899	Cumback, R. O.		Reliance Motor Truck Co.	Owosso, Mich.
1906	Cunningham, D. W.		A. S. M., Mo. Pac. Ry.	Baring Cross, Ark.
1900	Curley, M. S.			Memphis, Tenn.
1903	Curry, H. M.		G. M. M., Northern Pacific	St. Paul, Minn.
1903	Curtis, Theo. H.		Chicago Association of Commerce	Chicago, Ill.
1904	Cutler, T. J.		M. M., Northern Pacific	Spokane, Wash.
1909	Dalton, Wm.		C. E., American Loco. Co.	Schenectady, N. Y.
1911	Darlew, A. M.		M. E., Buffalo & Susquehanna R. R.	Galeton, Pa.
1899	Davis, Chas. H.		Barclay, R. R.	So. Yarmouth, Mass.
1906	Davis, David E.		M. M., Boston & Maine	Concord, N. H.
1892	Davis, Ed. E.			Newmarket, N. H.
1911	Davis, J. E.		M. M., Hocking Valley Ry.	Columbus, Ohio.
1909	Davis, J. H.		Elec. Engr., Baltimore & Ohio	Baltimore, Md.
1910	Davis, Jos.		M. M., Penna. R. R.	Harrisburg, Pa.
1911	Davis, T. K.		D. F., Missouri, Okla. & Gulf Ry.	Wapanuca, Okla.
1900	Davisson, F. E.		S. M., San Pedro, Los Angeles & Salt Lake.	Los Angeles, Cal.
1897	Dawson, E.		M. M., Ariz. & New Mex. R. R.	Clifton, Ariz.
1910	Dawson, L. L.		S. M. P., Ft. W. & D. C. Ry.	Childress, Texas.
1891	Deems, J. F.		Prest. Ward Equipment Co.	New York City.
1905	Deeter, D. H.		M. M., Philadelphia & Reading	Reading, Pa.
1896	DeGress, Chas.			Avenida 16 de Septiembre No. 18, Mexico, D. F
1897	Delaney, C. A.			
1905	Delaney, S. J.		M. M., N. Y. C. & H. R. R. R.	West Albany, N. Y.
1899	Delano, F. A.		Prest., Wabash	Chicago, Ill.
1900	Demarest, T. W.		S. M. P., Pennsylvania Lines	Ft. Wayne, Ind.
1909	De Pue, G. T.		M. M., Erie	Galion, Ohio.
1905	Desmond, D. G.		M. M., Morgantown & Kingwood	Morgantown, W. Va.
1903	Deverell, A. C.		A. S. M. P., Great Northern	St. Paul, Minn.
1907	De Voy, J. F.		A. S. M. P., Chicago, Milwaukee & St. Paul.	W. Milwaukee, Wis.
1905	Dewey, J. J.		S. M., Amer. Laundry Mach. Mfg. Co.	Rochester, N. Y.
1896	Dickerson, S. K.		A.S.M.P.,Lake Shore & Mich. Southern	Cleveland, Ohio.
1902	Dickson, Geo.		Baldwin Locomotive Works	Philadelphia, Pa.
1887	Dickson, G. L.		American Locomotive Co.	Scranton, Pa.

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1905	Dickson, John	M. M.,	Great Northern	Devils Lake, N. D.
1907	Diehr, C. P	M. M.,	N. Y. Central & Hudson River	Jersey Shore, Pa.
1900	Dillon, S. J	M. M.,	Pennsylvania	Camden, N. J.
1905	Dinan, Arthur	M. S.,	Atchison, Topeka & Santa Fe	Amarillo, Tex.
1905	Dinkel, M. C			926 South 13th st., Springfield, Ill.
1908	Dodds, E. I	Care of Mech'l Dept.,	Nor. Pac. Ry	St. Paul, Minn.
1897	Doebler, C. H	M. M.,	Ches. & Ohio Ry	Peru, Ind.
1905	Dolan, J. P	M. M.,	St. Louis & No. Arkansas	Eureka Springs, Ark.
1898	Dolan, S. M	M. M.,	Missouri Pacific	Sedalia, Mo.
1904	Dooley, W. H	S. M. P.,	Cin., New Orleans & Tex. Pac.	Ludlow, Ky.
1907	Dorsey, J. P			
1911	Dougherty, W. Q	M. M.,	Mobile & Ohio R. R. Co	Jackson, Tenn.
1863	Dow, Jas. M			Kenton, Ohio.
1908	Dresser, K. L	M. M.,	Chgo., Cin. & Lo	Peru, Ind.
1908	Dreyfus, T. F	Care of Balt. & Ohio R. R.		Wheeling, W. Va.
1893	Drury, Michael J	M. S.,	Atchison, Topeka & Santa Fe	La Junta, Colo.
1911	Duffey, G. J	M. M.,	Lake Erie & Western Ry	Lima, Ohio.
1904	Dunham, W. E	S. M. P. & M.,	Chicago & North Western	Winona, Minn.
1910	Dunlap, W. H	M. M.,	L. & N. R. R	Covington, Ky.
1896	*Dunn, J. F*	190 *S. M. P., Oregon Short Line*		*Salt Lake City, Utah.*
1904	Durborow, R. N	G. S. M. P.,	Pennsylvania	Altoona, Pa.
1910	Durham, Geo	M. M.,	L. & N. R. R	Louisville, Ky.
1906	Durham, H. P	S. M. P.,	Tehuantepec, National	Rincon, Ant., Oaxaca, Mex.
1906	Durrell, D. J	M. M.,	Pennsylvania Lines	Cincinnati, Ohio.
1911	Eden, E. S	M. M.,	Central New England R. R	Hartford, Conn.
1906	Edmonds, Geo. S	M. M.,	D. & H. Co	Oneonta, N. Y.
1905	Edmondson, W. G	E. of T.,	Philadelphia & Reading	Reading, Pa.
1909	Edwards, J. B	M. M.,	Col., Newberry & Laurens	Columbus, S. C.
1899	Egan, J. A	M. M.,	N. W. Ry. of Mex	Madera-Chih-Mex.
1900	Elden, Edw	M. M.,	N. Y. C. & H. R. R. R	East Buffalo, N. Y.
1909	Elliott, G. G	C. M. E.,	Central South African Rys	Johannesburg, S. A.
1906	Elliott, J. B	G. M. M.,	Canadian Pacific	Montreal, Can.
1908	Elliott, J. B	M. M.,	Baltimore & Ohio	New Castle, Pa.
1910	Elmer, Wm	M. M.,	Penna. R. R	Pittsburgh, Pa.
1906	Elorida, Manuel	Gen. Insp. Mach.,	Argentine Govt. Ry	New York City.
1901	Emerson, G. H	S. M. P.,	Great Northern	St. Paul, Minn.
1906	Emerson, H	30 Church St		New York City.
1911	Emory, J. B	M. M.,	Texarkana & Ft. Smith Ry	Texarkana, Tex.
1893	English, Richard			1794 Folsom st., San Francisco, Cal
1905	Enright, J. F	S. M. P.,	D. & R. G. R. R	Denver, Colo.
1898	Ettinger, R. L	C. M. E.,	Southern	Washington, D. C.
1908	Evans, R. C	Care of B. & O. S. W. R.	R	Washington, Ind.
1900	Ewing, J. J	M. E.,	Chesapeake & Ohio	Richmond, Va.
1908	Fairbank, J. F	M. M.,	Malvern & Freer Valley	Malvern, Ark.
1900	Feeley, T. M	M. M.,	Miss. Cent. R. R	Hattiesburg, Miss.
1904	Ferguson, F. G	Cordova & Rosario		Nuevo Alberdi, Arg. Rep., S. A.
1905	Ferguson, L. B	M. M.,	Vicksburg, Shreveport & Pacific	Monroe, La.
1904	Fetner, W. H	M. M.,	Central of Georgia	Macon, Ga.
1901	Fildes, Thos	Gold Car Htg. & Ltg.	Co	Richmond Hill, L. I., N. Y.
1907	Finch, Roland			Port Arthur, Russian China
1907	Fisher, O. A			4408 Indiana ave., Chicago, Ill.
1910	Fitzgerald, D. E	A. S. M. P.,	St. L. & S. F. R. R	Springfield, Mo.
1909	Fitzgerald, D. W	M. M.,	Gal., Harrisburg & San Antonio	El Paso, Tex.

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1905	Fitzgerald, W. T.		G. F., R. I. Lines	Estherville, Iowa.
1892	Fitzmorris, Jas.		M. M., Chicago Junction	Union Stock Yards, Chicago, Ill.
1908	Fitzsimmons, E. S.		M. M., Erie	Hornell, N. Y.
1906	Flavin, J. T.		M. M., Chgo., Ind. & Southern	Kankakee, Ill.
1903	Flory, B. P.		S. M. P., N. Y., Ontario & Western	Middletown, N. Y.
1909	Flynn, Walter H.		M. M., Michigan Central	St. Thomas, Ont., Can.
1901	*Fogg, J. W.*	39	*M. M., B. & O. C. T. Ry*	*East Chicago, Ind.*
1896	*Foque, T. A.*	155	*M. S., M. St. Paul & Sault Ste. Marie*	*Minneapolis, Minn.*
1900	Forsyth, A.		S. S., Chicago, Burlington & Quincy	Aurora, Ill.
1888	Forsyth, Wm.		M. E., *The Railway Age Gazette*	Chicago, Ill.
1908	Foster, O. M.		M. M., L. S. & M. S. Ry.	Elkhart, Ind.
1908	Foster, W. H.		M. M., N. Y. Central & Hudson River	High Bridge, N. Y.
1904	Foster, W. T.		Supt., Tennessee Copper Co.'s Ry	Copperhill, Tenn.
1877	Fowle, I. W.			Riverside, Cal.
1907	Fowler, Henry		C. M. E., Midland Ry. of England	Derby, England.
1907	Foyle, Chas. E.			100 Third st., Towands, Pa.
1906	Franey, M. D.		A. M. M., Lake Shore & Mich. Southern	Collinwood, Ohio.
1907	Fraps, J. C.		M. M., Aberdeen & Ashboro	Biscoe, N. C.
1907	Fraser, Thos.		M. M., Algoma Central	Sault Ste. Marie, Ont.
1906	French, G. W.		M. M., Little Rock & Hot Spgs. Western	Hot Springs, Ark.
1891	French, R. E.			1444 9th ave., Oakland, Cal.
1906	Friere, de Silva, J. G.		S. M. P., Central Ry. of Brazil	Rio de Janeiro, Brazil, S. A.
1904	Fries, A. J.		M. M., Boston & Albany	Springfield, Mass.
1903	Fryburg, F. M.		G. M. M., Great Northern	Minot, N. D.
1890	*Fuller, C. E.*	234	*A. G. M., Union Pacific*	*Omaha, Neb.*
1907	Fulmor, J. H.		M. M., Pennsylvania	Pottsville, Pa.
1897	Gaines, F. F.		S. M. P., Central of Georgia	Savannah, Ga.
1904	Gairns, A. H.		Supt., Central Loco. & Car Wks.	Chicago, Ill.
1901	Gallagher, G. A.		M. M., Southern Indiana	Bedford, Ind.
1908	Gallaudet, D.		M. M., Baltimore & Ohio	Garrett, Ind.
1904	Galloway, W. S.			Baltimore, Md.
1911	Gardner, G. C.		G. F. M. P., Penna. R. R.	Jersey City, N. J.
1910	Gardner, Henry		Asst. Supt. Apprentices, N. Y. C. Lines	New York City.
1887	Garstang, Wm.		S. M. P., C. C. C. & St. L.	Indianapolis, Ind.
1900	Gaskins, W. B.		Care of Oregon & Wash. Nav. Co.	Portland, Oregon.
1908	Gaspar, Charles L.			Fond du Lac, Wis.
1903	Gauthier, Jesse		M. M., Copper Range	Houghton, Mich.
1886	Gentry, T. W.		American Locomotive Co.	Richmond, Va.
1899	Gibb, T. M.		G. S., Crystal River	Redstone, Colo.
1888	Gibbs, A. W.		C. M. E., Pennsylvania Lines	Philadelphia, Pa.
1890	Gibbs, George			10 Bridge st., New York.
1909	Gibbs, J. W.		G. F., Southern Ry.	Asheville, N. C.
1902	Gibson, J. A.		M. M., C. C. C. & St. L.	Urbana, Ill.
1904	Gilbert, E. B.		Spl. Agt. M. P. Dept., Bessemer & Lake Erie	Greenville, Pa.
1911	Giles, C. F.		S. M., Louisville & Nashville R. R.	Louisville, Ky.
1896	Gill, John			Chicago, Ill.
1910	Gill, Wm.		M. M., Iowa Central Ry.	Marshalltown, Iowa.
1905	Gillett, L. D.		M. M., Norfolk & Western	Bluefield, W. Va.
1891	Gillis, H. A.			Home Life Building, Washington, D C.
1893	Gilmour, George		Travelers' Insurance Co.	Hartford, Conn.
1891	Glass, John C.		M. M., Pennsylvania	Verona, Pa.
1905	Goodale, R. J.			Wichita Falls, Tex.
1911	Goodall, C. N.		Mgr., Robt. Stephenson & Co.	Darlington, England.
1904	Goodman, J. E.		M. M., Northern Pacific	Duluth, Minn.
1907	Goodrich, G. P.		M. M., Ft. Smith & Western	Ft. Smith, A

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JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1905	Goodrich, Max	M. M.,	New York & Ottawa	Ottawa, Ont., Can.
1880	Gordon, H. D			New York.
1909	Gorey, E. H	G. F.,	Louisville & Nashville	Paris, Ky.
1906	Gossett, C. E	M. M.,	M. & St. L. Ry	Minneapolis, Minn.
1900	Gould, J. E	S. M. P.,	Norfolk & Southern	Berkley, Va.
1904	Gould, J. R	S. M. P.,	Chesapeake & Ohio	Richmond, Va.
1899	Gould, R		Buenos Ayres Great Southern	Pinecroft, Pyrford, Eng.
1911	Graburn, A. L	M. E.,	Can. Nor. Ry	Toronto, Ont., Can.
1892	Graham, Charles			Scranton, Pa.
1894	Graham, J. A	G. F.,	Louisville & Nashville	Columbia, Tenn.
1903	Grandy, W. S	D. F.,	Atchison, Topeka & Santa Fe	Bakersfield, Cal.
1906	Gray, B. H	S. M. P.,	N. O., Mobile & Chicago	Mobile, Ala.
1906	Gray, G. M	S. M. P.,	Bessemer & Lake Erie	Greenville, Pa.
1889	Greatsinger, J. L	2d V.-P.,	Elmira, Corning & Waverly Ry	Elmira, N. Y.
1897	Greaven, Luis	S. M. P.,	Buenos Ayres Gt. Sou	Buenos Ayres, Arg. Rep., S. A.
1905	Green, H			Chicago, Ill.
1895	Green, Wilbur	M. M.,	San Antonio & Aransas Pass	Yoakum, Tex.
1905	Greenwood, B. E	G. F.,	Seaboard Air Line Ry	Portsmouth, Va.
1909	Greenwood, H. F	G. F.,	N. & W. Ry	Roanoke, Va.
1911	Gregory, C. F	M. M.,	Manufacturers' Ry. of St. Louis	St. Louis, Mo.
1907	Griffith, R	M. M.,	Uintah R. R	Atchee, Colo.
1908	Grimshaw, F. G	M. M.,	Penn. R. R	Camden, N. J.
1908	Gross, E. G	M. M.,	Central of Georgia	Columbus, Ga.
1893	Gross, R. J	U. S.	Radiator Co	Dunkirk, N. Y.
1896	Groves, J. R	Colo. Mid. R. R		Colorado Springs, Colo.
1900	Gurry, Geo	G. S.,	American Locomotive Co	Allegheny, Pa.
1906	Guthbrod, F. W			New York, N. Y.
1909	Haggett, E. C	Asst. Supt.	Amer. Loco. Co	Dunkirk, N. Y.
1910	Haig, M. H	M. E.,	A. T. & S. F. Ry	Topeka, Kan.
1893	Hainen, J	S. M. P.,	Southern	Greensboro, N. C.
1898	Hair, John			Cincinnati, Ohio.
1906	Hale, H. H	M. M.,	C. H. & D. Ry	Cincinnati, Ohio.
1904	Hall, Chas. S	M. M.,	Boston & Maine	Springfield, Mass.
1908	Hamilton, Taber	M. M.,	Cumb. Valley	Chambersburg, Pa.
1907	Hamilton, W. H			Chanute, Kan.
1902	*Hammett, P. M*	167 *S. M. P.,*	*Maine Central*	*Portland, Me.*
1905	Hammond, G. O	N. Y. Air	Brake Co	Watertown, N. Y.
1891	Hancock, Geo. A	S. M. P.,	St. Louis & San Francisco	Springfield, Mo.
1893	Hancock, Wm. S	Waters-Pierce	Oil Co	St. Louis, Mo.
1908	Hanlin, J. J	M. M.,	Seaboard Air Line	Atlanta, Ga.
1909	Hardie, Henry	M. M.,	Louisville & Nashville	Corbin, Ky.
1905	Harkom, J. W			Melbourne, Que.
1906	Harrigan, P. J	M. M.,	Baltimore & Ohio	Connellsville, Pa.
1906	Harrington, H. H	M. M.,	Erie	Susquehanna, Pa.
1907	Harris, C. M	M. M.,	Washington Terminal	Washington, D. C.
1902	Harris, J. D			Roland Park, Md.
1898	Harrison, F. J	S. M. P.,	Buffalo, Rochester & Pittsburg	Du Bois, Pa.
1903	Hartigan, B	G. F.,	Rutland	Rutland, Vt.
1901	Haselton, G. H			West Albany, N. Y.
1889	Haskell, B			Franklin, Pa.
1910	Hassett, M. W	M. M.,	N. Y. C. Lines	E. Buffalo, N. Y.
1888	Hassman, Wm	M. M.,	Peoria & Pekin Union	Peoria, Ill.
1910	Hathaway, C. B			
1905	Hatz, G. K	S. S.,	Union Pacific	Omaha, Neb.
1909	Haug, Harry	M. M.,	Brownstone & Middleton	Waltonville, Pa.

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1900	Hawkins, B. H.		M. M., Del., Lack. & Western	Buffalo, N. Y.
1903	Hawkins, R. D.		M. E., Great Northern	St. Paul, Minn.
1908	Hayes, C. W.		M. M., Blue Ridge Ry	Anderson, S. C.
1906	Hayes, J. T.		M. M., Grand Rapids & Indiana	Grand Rapids, Mich.
1903	Hayes, W. C.		Supt. Loco. Operation, Erie	New York City.
1905	Haynen, W. J.		J. J. Newman Lumber Co	Hattiesburg, Miss.
1896	Hayward, H. S.		S. M. P., Pennsylvania	Jersey City, N. J.
1891	Hedley, F.		G. M., Interborough R. T. Ry. Co	New York City.
1887	Heintzlemen, T. W.		S. M. P., Southern Pacific	Sacramento, Cal.
1911	Heiser, W. F.		M. M., C. & E. I. R. R	Villa Grove, Ill.
1892	Henderson, G. R			500 N. Broad St., Philadelphia, Pa.
1910	Henry, J. M.		M. M., Penna. R. R	Sunbury, Pa.
1907	Henry, Wm.		M. M., St. Louis & San Francisco	Monette, Mo.
1908	Henry, W. C. A.		S. M. P., Penna. Lines West	Columbus, Ohio.
1907	Herr, E. E.		M. M., Pennsylvania	Camden, N. J.
1903	Herr, H. T.			Duquesne, Ariz.
1908	Hess, Geo. F.		M. M., Balt. & Ohio	Lorain, Ohio.
1911	*Hess, G. F.*		*S. M., Kansas City Southern Ry*	*Pittsburg, Kan.*
1895	Hibbard, H. Wade		University of Missouri	Columbia, Mo.
1903	Hickey, F. P.		American Locomotive Co	Richmond, Va.
1911	Hickey, J. E.		M. S., Mexico Northwestern Ry	Madera, Chih., Mexico.
1901	Hickey, P. J.		M. M., C. C. C. & St. L. Ry	Mattoon, Ill.
1906	Hicks, I. C.		M. M., Santa Fe Lines	San Bernardino, Cal.
1911	Hickson, Thos.		M. M., Chgo., Mil. & Gary. Ry	Rockford, Ill.
1890	Higgins, S.		G. M., N. Y., New Haven & Hartford	New Haven, Conn.
1901	Hildreth, F. F.		M. E., Vandalia	Terre Haute, Ind.
1901	Hilferty, C. D.			New York, N. Y.
1906	Hill, John.		M. M., M. & St. L. Ry	Minneapolis, Minn.
1896	Hill, Rufus			Moorestown, Burlington Co., N. J
1904	Hill, W. H.		M. M., Cornwall	Lebanon, Pa.
1908	Hill, W. J.		M. M., A. T. & S. F. Ry	Arkansas City, Kan.
1902	Hillman, C. R.		A. S. M. P., San Paulo	San Paulo, Brazil, S. A.
1906	Hinckley, A. C.		M. M., So. Pac. Co	Oakland, Cal.
1906	Hobbs, H. L.		Lafolette Iron Co	Lafolette, Tenn.
1902	Hobson, W. P.		A. M. M., Chesapeake & Ohio	Lexington, Ky.
1907	Hocking, Jas.		M. M., N. Y., New Haven & Hartford	South Boston, Mass.
1907	Hodges, A. H.		M. M., Baltimore & Ohio	Cumberland, Md.
1906	Hoffman, C. M.		S. M. P., St. L. B. & M. Ry	Kingsville, Texas.
1899	Hoffman, R. F.			10 Bloom st., Danville, Pa.
1908	Hoffmaster, F. S.		A. M. M., N. Y. P. & N. R. R	Cape Charles, Va.
1901	Hogan, C. H.		A. S. M. P., N. Y. C. & H. R. R. R.	32 Union sta., Albany, N. Y.
1892	Holland, W. D.		M. M., Philippine Ry	Iloilo, P. I.
1890	Homer, John C.		A. M. M., Cin., Hamilton & Dayton	Indianapolis, Ind.
1896	Hopwood, John.		Chile & Bolivia R. R	Antogofasta, Uyuni, S. A.
1896	*Horrigan, John.*	138	*S. M. P., E. J. & E., C. L. S. & E. Rys.*	*Joliet, Ill.*
1906	Horsey, A. W.		M. E., Canadian Pacific	Montreal, Can.
1892	Howard, C. H.			St. Louis, Mo.
1896	Howard, John.		S. M. P., New York Central Lines	New York City.
1905	Howe, H. B.			Everleigh, New So. Wales.
1909	Howson, G. N.		M. M., Southern	Alexandria, Va.
1899	Hudson, H. G			1436 84th st., Cleveland, Ohio.
1903	Hufman, W. H.		M. M., Chicago & North Western	Baraboo, Wis.
1905	Hume, E. S.		C. M. E., Western Australian Govt. Rys.	Midland Jct., Australia.
1890	Humphrey, A. L.		G. M., Westinghouse Air Brake Co	Pittsburg, Pa.
1906	Hungerford, S. J.		Supt. Loco. Wks., Can. Pac. Ry	Winnipeg, Man.
1904	Hunt, H. B.		American Locomotive Co	Ry. Ex. Bldg., Chicago, Ill.
1906	Hunter, G. S.		D. M. M., Kansas City Southern	Pittsburg, Kan.

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1905	Hunter, H. S		M. M., Philadelphia & Reading	Philadelphia, Pa.
1911	Hunter, W. C		M. M., Ga., Fla. & Ala. Ry	Bainbridge, Ga.
1896	Hyndman, F. T			1472 Chapel st., New Haven, Conn.
1900	Irwin, J. E		Indian Refining Co	Lawrenceville, Ill.
1908	Iwasaki, H		T. M., Imperial Govt. Rys	Tokyo, Japan.
1907	Jackson, Harry		Natl. R. R. of Mexico	Eagle Pass, Tex.
1911	Jackson, H. D		M. M., Charlotte Harbor & Northern Ry.	Arcadia, Fla.
1911	Jackson, O. S		S. M. P., Chgo., Terre Haute & S. E. R. R.	Terre Haute, Ind.
1911	Jackson, W. S		G. F., L. S. & M. S. Ry	Ashtabula, Ohio.
1908	Jacobs, H. W		A. S. M. P., A. T. & S. F. Ry	Topeka, Kan.
1907	James, Charles		M. M., Erie	Port Jarvis, N. Y.
1899	James, E. T		S. S., Lehigh Coal & Nav. Co	Lansford, Pa.
1910	James, J. M		M. M., Penna. R. R	Philadelphia, Pa.
1907	Jaynes, R. T		M. M., Lehigh & Hudson River	Warwick, N. Y.
1900	Jennings, Thos		M. M., Boston & Maine	Concord, N. H.
1890	Jennings, Wm			311 Herald Bldg., El Paso, Tex.
1896	Johnson, A. B		Baldwin Locomotive Works	Philadelphia, Pa.
1910	Johnson, Frank		M. M., Southern Ry	Sheffield, Ala.
1887	Johnson, L. R		S. M. P., Canadian Pacific	Montreal, Can.
1898	Johnson, R. H			Houston, Tex.
1903	Johnson, W. O			
1909	Johnston, J. M		M. M., St. Louis & San Francisco	St. Louis, Mo.
1910	Jones, C. H		M. M., H. & B. T. M. Ry	Saxton, Pa.
1909	Jones, E. F		M. M., Chgo. & Western Indiana Belt	Chicago, Ill.
1888	Joughins, G. R		M. S., Intercolonial	Moncton, N. B., Can.
1896	Justice, D. J			722 W. Chestnut st., Louisville, Ky.
1905	Kaderly, W. F		S. M. P., G. S. & F. Ry	Macon, Ga.
1910	Kadie, C. H		M. M., Southern Ry	Alexandria, Va.
1890	Kalbaugh, I. N		Coal & Coke Ry	Gassaway, W. Va.
1903	*Kapp, W. F*	51	*S. S. & M., Rich., Fred. & Potomac*	*Richmond, Va.*
1907	Kastlin, Jacob		Supt., Davenport Loco. Works	Davenport, Iowa.
1904	Kearney, Alex		A. S. M. P., Norfolk & Western	Roanoke, Va.
1892	*Keegan, Jas. E*	92	*S. M. P., Grand Rapids & Indiana*	*Grand Rapids, Mich.*
1909	Keenan, C. E		M. M., N. Y. Central & Hudson River	Durham, N. J.
1908	Kehoe, R. H		M. M., Nor. & Sou. Ry	New Bern, N. C.
1910	Keiser, C. B		M. M., Penna. R. R	New York City.
1904	Kellogg, W. L		S. M. P., C. H. & D. Ry	Cincinnati, Ohio.
1896	Kells, Willard		Asst. to G. S. M. P., A. C. L. Ry	Wilmington, N. C.
1896	Kelly, Wm		G. M. M., Great Northern	Spokane, Wash.
1904	Kendig, R. B		G. M. E., N. Y. C. Lines	New York City.
1901	Keyworth, T. E		Cuban Central Rys., Ltd	Sagua La Grande, Cuba.
1910	Kiesel, W. F., Jr		Asst. M. E., Penna. R. R	Altoona, Pa.
1911	Kight, H. R		M. M., Western Maryland R. R	Elkins, W. Va.
1908	Kiler, J. Q		M. M., C. Y. R. & P. Ry	Guaymas, Sonora, Mex
1903	Kilpatrick, J. B		A. S. M. P., Chicago, R. I. & Pacific	Chicago, Ill.
1900	Kilpatrick, R. F		A. S. M. P., Denver & Rio Grande	Denver, Colo.
1903	Kinnaird, L. S		M. M., Cleveland, Akron & Columbus	Mt. Vernon, Ohio.
1911	Kinney, C. D		M. M., Kanawha & Michigan Ry	Middleport, Ohio.
1909	Kinney, M. A		M. M., Hocking Valley	Columbus, Ohio.
1905	Kinney, W. H		M. M., New York, Ontario & Western	Carbondale, Pa.
1909	Kipp, A. R		M. S., Minn., St. P. & Sault Ste. Marie	Fond du Lac, Wis.

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1904	Kirkpatrick, Jas		M. M., Baltimore & Ohio	Newark, Ohio.
1902	Knight, Wm. Edw		S. M. P., Cuba R. R	Camaquay, Cuba.
1908	Knight, G. E		G. M. M., Cuba R. R	Camaquay, Cuba.
1911	Krassovsky, P. T		A. G. S. M. P., Moscow-Kazan R. R	Moscow, Russia.
1902	Krause, J. I		M. M., K. C. Southern	Mena, Ark.
1907	Kurman, A. G			Kane, Pa.
1905	Kyle, C		M. M., Canadian Pacific	Montreal, Que.
1899	Lachlan, Wm			Earls Court, London, Eng.
1909	Lancaster, T. C		G. F., Southern Ry	Birmingham, Ala.
1888	Lape, C. F			216 Stimson Block, Los Angeles, Cal.
1910	Larallee, J. L		A. M. M., National R. R. of Mexico	Cardenas, S. L. P., Mex.
1907	Larrey, T		Natl. Lines of Mexico	Mexico City, Mex.
1907	Larry, W. L		M. M., N. Y., New Haven & Hartford	Taunton, Mass.
1907	Latta, H. P			
1911	Laugton, G. H		M. M., Kansas City Southern Ry	Shreveport, La.
1905	Laurent, Theo		A. C. E., Paris & Orleans Ry	Paris, France.
1891	Lawes, T. A		M. M., Chicago, Terre Haute & Southeast.	Terre Haute, Ind.
1890	Leach, H. L			75 Wallingford Road, Brookline, Mass.
1903	Leach, W. B			383 Dorchester ave., South Boston, Mass.
1892	Lee, C. W			Greensboro, N. C.
1890	Leonard, A. G		Chgo. Junction Ry	Chicago, Ill.
1876	*Lewis, W. H*	697	*S. M. P., Norfolk & Western*	*Roanoke, Va.*
1909	Leyonmark, J. H		M. E., Chicago & Alton R. R	Bloomington, Ill.
1909	Likert, G. H		M. M., Union Pacific	Omaha, Neb.
1907	Lille, G. W			Pocatello, Idaho.
1904	Link, T. C			1504 Lincoln ave., Colorado Springs, Colo.
1909	Lipscombe, W. B		G. F., Southern Ry	Salem, Ala.
1907	Little, J. C		M. E., Chicago & North Western	Chicago, Ill.
1903	Litton, Francis H		Hull & Barnsley	Springhead, Hull, Eng.
1890	*Lloyd, T. S*	1287	*S. M. P., Dela., Lack. & Western*	*Scranton, Pa.*
1905	Lockwood, B. D		A. C. E., Pressed Steel Car Co	McKees Rocks, Pa.
1895	Lonergan, P. T			W. Springfield, Mass.
1907	Lord, A. W		S. M. P., Quincy & Torch Lake	Hancock, Mich.
1899	Lovell, Alfred			819 Harrison Bldg., Philadelphia, Pa.
1911	Lovell, F. A		M. M., Spanish American Iron Co	Felton Oriente, Cuba.
1911	Lucy, E. E		C. M. E., New South Wales Govt. Ry	Sydney, N. S. W.
1908	Luscombe, J. T		M. M., T. & O. C. Ry	Bucyrus, Ohio.
1903	Lyddon, H. A		G. L. F., Northern Pacific	N. Brainerd, Minn.
1910	Lynch, J. M		M. M., Honduras Ry	Honduras, Central Am.
1894	Lyon, Tracy		Westinghouse Electric & Mfg. Co	Pittsburg, Pa.
1903	MacBain, D. R		S. M. P., L. S. & M. S. Ry	Cleveland, Ohio.
1907	Macbeth, H. A		M. M., N. Y., Chicago & St. Louis	Conneaut, Ohio.
1890	Macfarlane, T. W		Mobile, Jackson & Kansas City	Richmond, Kan.
1899	Machesney, A. G		Baldwin Locomotive Works	Philadelphia, Pa.
1909	Machovec, E. E		M. M., A. T. & S. F. Ry	Argentine, Kan.
1876	Mackenzie, John			Cleveland, Ohio.
1905	Magarvey, J. R		American Locomotive Co	Dunkirk, N. Y.
1911	Mahar, T		M. M., N. Y. C. & H. R. R. R	North White Plains, N. Y
1896	Maher, P			Bloomington, Ill.
1896	Mahl, F. W		Care So. Pac. Co.,	135 Adams st., Chicago, Ill.
1911	Mahoney, W. H		D. M. M., Buenos Aires & Pacific Ry	Huinca, Renanco, Arg. Rep., S. A.
1910	Malloy, M. A		M. M., Penna. Lines	Pittsburgh, Pa.

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1899	Malone, I. M			Guadalajara, Jalisco, Mex.
1904	Malthaner, W		M. M., Delaware & Hudson	Green Island, N. Y.
1894	Manchester, A. E		S. M. P., C. M. & St. P	West Milwaukee, Wis.
1902	Manchester, H. C		A. S. M. P., Maine Central	Portland, Me.
1893	*Manning, J. H*	336	*S. M., Delaware & Hudson*	*Albany, N. Y.*
1905	Mannion, T. D		M. M., A. C. Ry	Camden, N. J.
1898	Marchbanks, James		Wellington & Manawater	Wellington, N. Z.
1908	Marea, M		M. M., T. St. L. & W. R. R	Frankfort, Ind.
1911	Mark, Hong		M. S., Canton, Hankow Ry	Wansha, Canton, China.
1911	Markey, Jas		M. M., Grand Trunk Ry	Toronto, Ont., Can.
1910	Marsh, F. E		A. M. M., Penna. R. R	Altoona, Pa.
1890	Marshall, E. S			St. Louis, Mo.
1906	Marshall, Thos		M. M., C. St. P. M. & O. Ry	St. Paul, Minn.
1891	Marshall, W. H		Prest., American Locomotive Co	New York City.
1908	Martin, E. L			El Paso, Tex.
1910	Martin, H. W		Supt., Mt. J. K. & R. Ry	Kushequa, Pa.
1908	Martin, J. P			
1909	Mathis, J. E		M. M., Georgia & Florida	Douglas, Ga.
1910	Matthews, G. H		M. M., N. O. T. & M. Ry	De Quincy, La.
1910	Maupin, J. D		M. M., T. & B. V. Ry	Teague, Texas.
1909	Maver, A. A		M. M., Grand Trunk	Montreal, Can.
1909	Maxfeld, H. H		M. M., Pennsylvania	Trenton, N. J.
1910	Maxwell, J. D		M. M., L. & N. R. R	Mobile, Ala.
1903	May, H. C		M. M., Louisville & Nashville	New Decatur, Ala.
1907	May, Walter		M. M., Cleve., Cin., Chicago & St. Louis	Louisville, Ky.
1904	Maysilles, J. H		Supt., Davenport Loco. Works	Davenport, Iowa.
1909	McAndrew, W. J		M. M., Delaware & Hudson Co	Carbondale, Pa.
1906	McArthur, F. A		M. M., St. Louis & San Francisco	Springfield, Mo.
1910	McCabe, Jos		M. M., N. Y. N. H. & H. R. R	New York City.
1905	McCarthy, M. J		S. S., C. C. C. & St. L. Ry	Indianapolis, Ind.
1908	McCarthy, T. W		M. M., C. R. I. & P. Ry	Horton, Kan.
1891	McConnell, J. H			Hollywood, Cal.
1896	McCormick, A		F. M. Hicks & Co	Chicago Heights, Ill.
1892	McCuen, J. P		C. N. O. & T. P. and A. G. S. Rys	Ludlow, Ky.
1903	McCuen, R. E		M. M., Lexington & Eastern	Lexington, Ky.
1891	McDonough, James		M. M., A. T. & S. F. Ry	Newton, Kan.
1905	McDougall, R. M		M. M., Morenci Southern	Morenci, Ariz.
1893	McElvaney, C. T		M. M., Missouri, Kansas & Texas	Denison, Tex.
1910	McFarland, Prof, H. B		E. of T., A. T. & S. F. Ry	Topeka, Kan.
1908	McGee, W. J		M. M., Tampa Northern	Tampa, Fla.
1908	McGill, A. M		M. M., Lehigh Valley	Wilkesbarre, Pa.
1905	McGoff, J. H		M. S., Atchison, Topeka & Santa Fe	Topeka, Kan.
1903	McGrath, J. T		S. M. P., C. & A. Ry	Bloomington, Ill.
1910	McGregor, A. A		M. M., L. & N. R. R	Louisville, Ky.
1911	McGuire, J. J		Gen. For., B. & O. R. R	Cleveland, Ohio.
1903	McHattie, T		S. M. P. & C. D., Central Vermont	St. Albans, Vt.
1890	McIntosh, Wm			Jersey City, N. J.
1893	McKee, G. S			413 3d National Bank Building, St. Louis, Mo.
1901	McKeen, W. R., Jr		C. E. Motor Car Dept., Union Pacific	Omaha, Neb.
1911	McLean, J. E		M. M., K. C. S. Ry	Pittsburg, Kan.
1896	McLean, W. J		M. M., Bell., Bay. & Brit. Col	Bellingham, Wash.
1906	McManamy, J		R. F. of E., Pere Marquette	Grand Rapids, Mich.
1894	McMasters, Chas. J		G. F., Rutland	Malone, N. Y.
1890	McNaughton, Jas		American Locomotive Co	Schenectady, N. Y.
1905	McNulty, F. M		M. M., Monongahela Connecting	Pittsburgh, Pa.
1909	McPherson, T. J			Schenectady, N. Y.
1905	McRae, J. A		M. E., Michigan Central	Detroit, Mich.

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JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1910	Meade, P. J.		G. F., Atlantic Coast Line R. R.	Jacksonville, Fla.
1911	Meehan, J. L.		M. M., Ashland Coal & Iron Co.	Ashland, Ky.
1907	Mechling, J. E.		M. M., Vandalia R. R.	Terre Haute, Ind.
1905	Meister, C. L.		M. E., Atlantic Coast Line	Wilmington, N. C.
1895	Mellin, C. J.		American Locomotive Co.	Schenectady, N. Y.
1900	Mendenhall, C. M.			2 Rector st., New York City.
1910	Mengal, J. C.		M. M., Penna. R. R.	Altoona, Pa.
1903	*Menzel, W. G.*			*Fond du Lac, Wis.*
1907	Meredith, H. P.		A. E. M. P., Penna. R. R.	Altoona, Pa.
1892	Mertsheimer, F.		G. S. M. P., K. C. M. & O. R. R.	Kansas City, Mo.
1887	Michael, J. B.		M. M., Southern	Knoxville, Tenn.
1889	*Miller, E. A.*	180	*S. M. P., N. Y. C. & St. L.*	*Cleveland, Ohio.*
1890	Miller, Geo. A.		M. M., Florida East Coast	St. Augustine, Fla.
1909	Miller, H. M.		M. M., Susquehanna & New York	Williamsport, Pa.
1903	Miller, J. B.		G. F., St. L. Southwestern of Texas	Waco, Tex.
1901	Miller, S. W.		American Locomotive Co.	Providence, R. I.
1903	Miller, W. J.		M. M., St. L. Southwestern of Texas	Tyler, Tex.
1903	Milliken, James		S. M. P., Phila., Balt. & Washington	Wilmington, Del.
1909	Mills, J. H.		M. M., Canadian Pacific	West Toronto, Ont., Can.
1893	Minshull, P. H.		M. M., N. Y. O. & W.	Middletown, N. Y.
1888	Minton, A. B.		M. M., Mobile & Ohio	Jackson, Tenn.
1908	Moan, E. G.			87 Maple st., Jersey City, N. J.
1903	Moir, William			St. Paul, Minn.
1898	Moler, A. L.		M. M., Frisco Lines	Beaumont, Tex.
1907	Moll, George		M. M., Philadelphia & Reading	Reading, Pa.
1908	Monfee, A. J.		M. M., Birmingham Southern R. R.	Pratt City, Ala.
1901	Monahan, J. J.		M. M., Louisville & Nashville	Pairs, Tenn.
1890	Monkhouse, H.		Rome Loco. & Mach. Works	Rome, N. Y.
1903	Monlaverde, F.		Paulista	Santos, Brazil.
1903	Monroe, M. S.		M. M., Chicago, Lake Shore & Eastern	Chicago, Ill.
1911	Montgomery, Chas.		M. M., Pere Marquette R. R.	St. Thomas, Ont., Can.
1910	Montgomery, H.		M. M., Penna. R. R.	Oil City, Pa.
1907	Montgomery, Hugh.		S. M. P., B. & A. Ry.	Milo Junction, Me.
1884	Montgomery, Wm.		M. M., Central R. R. of N. J.	Lakehurst, N. J.
1910	Mooney, T. H.		Asst. Supt., G. H. & S. A. Ry.	San Antonio, Tex.
1910	Moore, B. R.		S. M. P., Duluth & Iron Range	Two Harbors, Minn.
1896	Moran, Robert		M. M., Louisville & Nashville	Nashville, Tenn.
1907	Moran, W. F.		M. M., Southern	Sheffield, Ala.
1909	Morehead, L. B.		M. E., N. Y. C. & St. L. Ry.	Cleveland, Ohio.
1907	Moriarty, G. A.		M. M., N. Y., New Haven & Hartford	Providence, R. I.
1887	Morris, W. S.			813 W. Berry st., Ft. Wayne, Ind.
1906	Mowery, J. N.		M. M., N. Y. N. H. & H. R. R.	Waterbury, Conn.
1901	Muchnic, C. M.		American Locomotive Co.	New York, N. Y.
1899	Muhlfeld, J. E.		V. P., K. C. S. Ry.	Kansas City, Mo.
1905	Mullen, D. J.		M. M., C. C. C. & St. L.	Mt. Carmel, Ill.
1908	Mullinix, J. W.		S. M. P., C. R. I. & P. Ry.	Horton, Kan.
1904	Murphy, J. H.		M. M., Cin., New Orleans & Tex. Pac.	Ludlow, Ky.
1890	Murphy, P. H.		Murphy Car Roof Co.	East St. Louis, Ill.
1905	Murray, W. H.		R. H. Foreman, Wheeling & Lake Erie	Brewster, Ohio.
1903	Murrian, W. S.		S. M. P., Southern	Knoxville, Tenn.
1909	Myers, B. P.		M. M., International & Great Northern	San Antonio, Tex.
1909	Nascimento, Dr. Jose C. F. do		Loco. Dept., Central of Brazil Ry.	San Francisco, Xaview 894, Brazil, S. A.
1910	Nash, J. H.		Shop Supt., Ill. Cent. R. R.	Chicago, Ill.
1904	Needham, E. F.		S. L. & C. D., Wabash	Springfield, Ill.

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JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1911	Needham, H. S.		A. E. M. P., Penna. Lines	Columbus, Ohio.
1908	Neel, T. M., Jr.		M. E., A. B. & A. R. R.	Newberry, S. C.
1911	Nelson, C. B.		A. M. M., L. S. & M. S. Ry.	Elkhart, Ind.
1905	Nelson, E. D.		E. of T., Pennsylvania	Altoona, Pa.
1894	Nettleton, W. A.		G. S. M. P., C. R. I. & P. Ry.	Chicago, Ill.
1898	Neubert, G. T.			Oelwein, Iowa.
1892	Neuffer, John G.		S. M. P., Chgo. Great Western	Oelwein, Iowa.
1901	Neville, John		M. M., M. L. & D. Co.	Comey, Michoacan, Mex.
1908	New, W. E.		M. M., K. C. Belt Ry.	Kansas City, Mo.
1896	Neward, F. H.		M. M., Pontiac, Ox. & Northern	Pontiac, Mich.
1906	Newhouse, J. F.		M. M., Ken. & Ind. Bridge & R. R.	Louisville, Ky.
1875	Nicholson, Jno.		S. M. P. & M., St. L. B. & M. Ry.	Kingsville, Tex.
1908	Noble, L. C.			Fisher Bldg., Chicago, Ill.
1899	Nolan, J. P.		D. M. M., Morgan's L. & T. R. R. & S. S. Co.	Algiers, La.
1906	Noyes, C. T.		S. S., Southern Pacific	Sacramento, Cal.
1902	Nutt, Geo. B.		L. S., Egyptian State Ry.	Cairo, Egypt.
1896	Nuttall, W. H.		M. M., Manistee & Northeastern	Manistee, Mich.
1903	O'Hearne, J. E.		M. M., Wheeling & Lake Erie	Norwalk, Ohio.
1890	O'Herin, Wm.		S. M., Mo., Kan. & Tex.	Parsons, Kan.
1895	O'Leary, D.		M. M., Columbia & Puget Sound	Seattle, Wash.
1905	Oplinger, J. W.		S. M. P., Atlantic Coast Line	Waycross, Ga.
1901	Ord, C. R.		M. M., Canadian Pacific	McAdam Jct., N. B., Can.
1908	Osborne, C. H.		A. S. C. D., C. & N. W. Ry.	Chicago, Ill.
1908	Osborne, H. J.		M. M., C. R. I. & P. Ry.	Valley Jct., Iowa.
1908	Osborne, R. E.			Joplin, Mo.
1907	Oviatt, H. C.		M. M., N. Y., New Haven & Hartford	New Haven, Conn.
1906	Owens, W. H.		M. M., Southern	Manchester, Va.
1911	Page, C. N.		M. M., Lehigh Valley Ry.	Auburn, N. Y.
1910	Painter, J. H.		S. S., A. C. L. R. R.	Rocky Mount, N. C.
1901	Parish, Le Grand			30 Church st., New York City.
1900	Parker, M. B.			P. O. Box 1, Chattanooga, Tenn.
1901	Park, S. T.		S. M. P., Chicago & Eastern Illinois	Danville, Ill.
1903	Park, P. D.		M. M., Reid Newfoundland Co.'s	Whitbourne, N. F.
1909	Parra, M.		M. M., Mexican Ry.	Apizaco, Tlax., Mexico.
1903	Passmore, H. E.		M. M., Toledo & Ohio Central	Kenton, Ohio.
1879	Patterson, J. S.		Galena Signal Oil Co.	Cincinnati, Ohio.
1909	Patterson, Rob't.		M. M., Grand Trunk	Stratford, Ont., Can.
1903	Paul, W. M.		M. M., Gal., Houston & Henderson	Galveston, Tex.
1891	Paxton, Thos.		S. M. P., El Paso & South Western	El Paso, Tex.
1904	Pearce, J. S.		M. M., Norfolk & Western	Portsmouth, Ohio.
1903	Pearsall, D. M.		M. M., Atlantic Coast Line	Montgomery, Ala.
1899	Pearse, H.		Buenos Ayres & Rosario, La Quinta	Rosario de Santa Fe, Arg. Rep., S. A.
1899	Pennington, J. H.			1047 Broadway, New York.
1910	Perrine, W. M.		M. M., C. R. R. of N. J.	Jersey City, N. J.
1908	Petries, L. A.		M. M., Oaho Ry. & Land Co.	Honolulu, Hawaii.
1897	Peyton, H. T.		M. M., Atchison, Topeka & Santa Fe	La Junta, Colo.
1907	Pfaffin, Louis.		M. M., Indianapolis Union	Indianapolis, Ind.
1907	Pfahler, F. P.		M. E., Wheeling & Lake Erie	Brewster, Ohio.
1897	Pflager, H. M.		Commonwealth Steel Co.	St. Louis, Mo.
1909	Phillips, A. B.		S. M. P., Tonapah & Goldfield	Tonapah, Nev.
1900	Phillips, C.		M. M., New Orleans & Northeastern	Meridian, Miss.
1906	Phipps, S.		M. M., Canadian Pacific	Vancouver, B. C.

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1905	Pierce, F. M.		M. M., Turner & Co.	Worth, Ga.
1902	Pilcher, J. A.		M. E., Norfolk & Western	Roanoke, Va.
1901	Place, F. E.		Buda Foundry & Machine Co.	Harvey, Ill.
1900	Plank, P. D.		M. M., Louisville, Hend. & St. Louis	Cloverport, Ky.
1903	Platt, J. G.			Baltimore, Md.
1897	Pollitt, Harry		Great Central	Fernlea, Altricham, Cheshire, Eng.
1906	Poole, A. J.		S. M. P., Seaboard Air Line	Portsmouth, Va.
1900	Post, W. F.		Watkins Foundry & Machine Co.	Hattiesburg, Miss.
1897	Potton, J.		M. M., Texas & Pacific	Big Springs, Tex.
1910	Potts, C. H.		M. M., Penna. R. R.	Renovo, Pa.
1905	Powell, V. U.		M. M., Illinois Central	Mattoon, Ill.
1906	Powers, M. J.		M. M., D. & R. G. R. R.	Denver, Colo.
1903	Pratt, E.W.		A. S. M. P., Chicago & North Western	Chicago, Ill.
1907	Prendergast, A. P.		M. M., Baltimore & Ohio	Baltimore, Md
1907	Prendergast, J. L.		M. M., Baltimore & Ohio	Glenwood, Pa.
1891	Prescott, C. H.		M. M., Spokane International	Spokane, Wash.
1905	Preston, Robert		M. M., Canadian Pacific	Toronto Jct., Toronto, Can.
1900	Prince, S. F., Jr			122 W. 49th st., New York City.
1905	Purdy, Jos. B.		M. M., Hilo	Hilo, Hawaii.
1890	Purves, T. B., Jr			Boston, Mass.
1888	*Quayle, Robert,*	1307	*S. M. P. & M., Chicago & N. W.*	*Chicago, Ill.*
1895	Quereau, C. H.		S. E. E., N. Y. C. & H. R. R. R.	New York, N. Y.
1908	Quigley, Jos.		M. M., C. N. O. & T. P. Ry.	Chattanooga, Tenn.
1909	Rae, Clark H.		G. M. M., Louisville & Nashville	Louisville, Ky.
1911	Ramage, J. C.		Supt. Tests, Southern Ry.	Alexandria, Va.
1908	Randolph, J. L.		M. M., B. & M. R. R.	E. Cambridge, Mass.
1890	Randolph, L. S.		Virginia Polytechnic Institute	Blacksburg, Va
1911	Reading, R. K.		S. M. P., Penna. R. R.	Altoona, Pa.
1910	Reagan, F. H.		Supt., D. L. & W.	Scranton, Pa.
1903	Records, J. W.			Cimarron, N. M.
1901	Redding, D. J.		M. M., Pittsburgh & Lake Erie	McKee's Rocks, Pa.
1911	Reed, F. C.		M. M., St. Louis, Iron Mountain & So. Ry.	McGehee, Ark.
1904	Reeves, P. H.		M. M., Baltimore & Ohio	Chillicothe, Ohio.
1909	Reid, H. G.		M. M., Canadian Pacific	North Bay, Ont., Can.
1902	Reid, W. L.		American Locomotive Co.	Schenectady, N. Y.
1883	Renshaw, W.			Chicago, Ill.
1896	Reynolds, O. H			310 W. 12th st., New York City.
1899	Rhodes, L. B.			Candler Bldg., Altanta, Ga.
1911	Rhuark, F. W.		M. M., B. & O. R. R.	Lorain, Ohio.
1909	Riberio, J. A.		Loco. Supt., Cent. Rys. of Brazil	Engenho do Dentro, Rio de Janeiro, Brazil, S. A.
1905	Rice, J. H.		M. M., DeQueen & Eastern	De Queen, Ark.
1907	Richardson, L. A.		M. M., Chicago, Rock Island & Pacific.	Trenton, Mo.
1901	Richmond, W. H.		M. M., Lake Superior & Ishpeming	Marquette, Mich.
1910	Ridgway, Geo.		Asst. Loco. Supt., Dublin & Southeastern Rys.	Dublin, Ireland.
1909	Ridgway, H. W.		M. M., Colo. & Southern	Denver, Colo.
1907	Rieckman, W. H.		A. M. M., Boston & Maine	Mechanicsville, N. Y.
1909	Riegel, S. S.		M. E., Dela., Lack. & Western	Scranton, Pa.
1894	Riley, George N.		M. M., McKeesport Connecting	Pittsburgh, Pa.
1909	Rink, Geo. W.		M. E., Central R. R. of N. J.	Elizabethport, N. J.
1902	Robb, J. M.		M. M., Chicago Great Western	Chicago, Ill.
1901	Robb, W. D.		S. M. P., Grand Trunk	Montreal, P. Q.

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1909	Roberts, C. F.		A. S. M. P., Havana Central Rys., United Rys. of Havana	Havana, Cuba.
1901	Roberts, Jos.		M. M., Union Pacific	Kansas City, Kan.
1910	Robertson, D. D.		M. M., L. V. Ry	Wilkesbarre, Pa.
1903	Robinson, Maynard.		M. M., Gulf, Colo. & Santa Fe	Temple, Tex.
1909	Robinson, W. H.		G. M., Bolivia Ry. Co	Antofagasta, Chili, S. A.
1906	Roesch, F. P.		M. M., El Paso & Southwestern	Douglas, Okla.
1896	Rogers, M. J			1008 West 24th st., Kansas City, Mo.
1903	Rogers, R. H.		G. Insp., Erie R. R.	Paterson, N. J.
1910	Roland, W. I.		M. M., B. & O. R. R.	Grafton, W. Va.
1909	Rollings, E. O.		A. M. M., L. & N. R. R.	Howell, Ind.
1900	Roope, Thos.		S. M. P., Chicago, Burl. & Quincy	Lincoln, Neb.
1896	Rosing, W. H. V.		A. G. M., St. L. & S. F. Ry	St. Louis, Mo.
1910	Roth, H. L.		G. F., C. N. O. & T. P. Ry	Ludlow, Ky.
1895	Royal, C. B			101 Holly court, Oak Park, Ill.
1898	Rumney, T.		G. M. S., Erie	New York, N. Y.
1896	Rusch, Peter C.		M. M., Buffalo, Rochester & Pittsburgh	Bradford, Pa.
1907	Russell, A. C			P. O. Box 74, San Marcial, N. M.
1907	Russell, W. B.		Director, Franklin Union	Boston, Mass.
1891	Ryan, J. J.		S. M. P., Southern Pacific	Houston, Tex.
1892	Ryan, Patrick		M. M., Louisville & Nashville	Russellville, Ky.
1892	Sague, J. E.		Public Service Commission, 2d District	Albany, N. Y.
1906	Sakuma, T.		M. E., Imp. Govt. Ry	Uyano, Tokyo, Japan.
1887	Sample, N. W.		Baldwin Locomotive Works	Philadelphia, Pa.
1896	Sanderson, R. P. C.		Baldwin Locomotive Works	Philadelphia, Pa.
1908	Sasser, E. C.		M. M., Southern Ry	Spencer, N. C.
1909	Sasser, J. W.		M. M., Seaboard Air Line	Savannah, Ga.
1905	Schlacks, W. J			Old Colony Bldg., Chicago, Ill.
1904	Schlafge, Wm.		M. S., Erie	Jersey City, N. J.
1911	Schultheiss, Rupert			Sacramento, Cal.
1901	Seabrook, C. H.		S. M., I. & G. N. Ry	Palestine, Tex.
1907	Sechrist, T. O.		M. M., Cin., N. O. & Texas Pacific	Somerset, Ky.
1907	Seddon, C. W.		S. M. P., Duluth, Missabe & Northern	Proctor (St. Louis Co.), Minn.
1900	Seidell, G. W.		Supt. Shops, Chicago, R. I. & Pacific	Silvis, Ill.
1900	Seley, C. A.		M. E., Chicago, Rock Island & Pacific	Chicago, Ill.
1907	Shaff, C. D., Jr.		M. M., N. Y. Central & Hudson River	Watertown, N. Y.
1908	Sharp, C. L.		G. F., Rock Island Lines	El Reno, Okla.
1908	Shaw, B. S.		M. M., Durham & Southern Ry	Durham, N. C.
1906	Shea, R. T.		Insp. Tools and Mach., N. Y. C. Lines	New York City.
1903	Sheahan, J. F.		M. M., I. & G. N. Ry	Palestine, Tex.
1907	Shelaberger, John.		M. M., Southern Pacific Co	Bakersfield, Cal.
1910	Shelby, C. K.		M. M., Nor. Cent. R. R.	Elmira, N. Y.
1899	Shepard, L. A.		Atha Steel Casting Co	Newark, N. J.
1903	Shepard, Samuel.		M. M., Minn., St. Paul & Sault Ste. Marie	Gladstone, Mich.
1905	Shields, A.		M. M., Canadian Northern	Winnipeg, Man., Can.
1904	Shoemaker, H.		M. M., Del., Lack. & Western	Scranton, Pa.
1906	Shreve, W. J.		M. M., Minn. & Rainy River	Deer River, Minn.
1910	Sibbald, John.		M. M., Fonda, Johnstown & Gloversville Ry	Gloversville, N. Y.
1883	Sinclair, Angus			114 Liberty st., New York City.
1900	Singer, Frank			Canon City, Colo.
1892	Sinott, W.		M. M., Baltimore & Ohio	58th st., Philadelphia, Pa.
1889	Skinner, H. M. C.			579 Durfee st., Fall River, Mass.
1893	Slater, F.		M. M., C. & N. W. Ry	Escanaba, Mich.

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1894	Slayton, C. E.		A. S., St. J. & G. I. Ry.	St Joseph, Mo.
1900	Slayton, F. T.		S M. P., Va. Ry.	Princeton, Va.
1909	Small, Fred F.		M. E., Pacific Electric	Los Angeles, Cal.
1889	*Small, H. J.*	1170	*G. S. M. P., Southern Pacific*	*San Francisco, Cal.*
1908	*Small, J. W.*		*S. M., Mo. Pac. Ry.*	*St. Louis, Mo.*
1909	Smithurst, T.		S. M. P. & R. S., Interoceanic.	Puebla, Mex.
1903	Smith, C. B.			Melrose, Mass.
1900	Smith, D. A.		M. M., Boston & Maine	East Somerville, Mass.
1904	Smith, E. J.		M. M., Atlantic Coast Line	Florence, S. C.
1893	Smith, F. B.			Indianapolis, Ind.
1896	Smith, F. C.			
1900	Smith, F. J.		D. M. M., B. & O. S. W.	Washington, Ind.
1910	Smith, H. E.		Chemist, L. S. & M. S. Ry.	Collinwood, Ohio.
1892	Smith, John L.		G. F., Pitts., Shawmut & Northern	St. Marys, Pa.
1910	Smith, L. K.		A. M. M., Wabash R. R.	Moberly, Mo.
1900	Smith, L. L.		M. M., Chicago & Milwaukee Electric	Highwood, Ill.
1907	Smith, M. W.		M. M., Tampa & Jacksonville	Gainesville, Fla.
1899	Smith, R. D.		S. M. P., B. & A. R. R.	Boston, Mass.
1905	*Smith, R. E.*	538	*G. S. M. P., Atlantic Coast Line*	*Wilmington, N. C.*
1902	Smith, Wm.		Garlock Pkg. Co.	New York, N. Y.
1869	Smith, W. T.		M. M., Chesapeake & Ohio	Covington, Ky.
1906	Smock, F. A.		M. M., P. R. R.	Jersey City, N. J.
1910	Sneck, Harry		M. M., B. R. & P. Ry.	E. Salamanca, N. Y.
1911	Snell, E. J.		M. M., N. Y. C. & H. R. R. R.	Corning, N. Y.
1908	Snyder, C. A.		M. M., E. P. & S. W. R. R.	Douglas, Ariz.
1907	Spearman, W. J.		M. M., Mo. Pacific	Coffeyville, Kan.
1911	Spengler, C. H.		M. M., Butte, Anaconda & Pacific Ry.	Anaconda, Mont.
1907	Sprowl, N. E.		M. M., Atlantic Coast Line	Savannah, Ga.
1901	Squire, W. C.			209 Western Union Bldg., Chicago, Ill.
1909	Staley, H. F.		M. M., Caro, Clinchfield & Ohio	Erwin, Tenn.
1898	Stansbury, C. M.		M. M., Boca & Loyalton	Loyalton, Cal.
1910	Stearns, W. A.		M. E., L. & N. R. R.	Louisville, Ky.
1908	Steel, Frank M.		M. M., N. Y. C. & H. R. R. R.	East Buffalo, N. Y.
1911	Stephens, H. H.		G. F., A. T. & S. F. Ry.	Arkansas City, Kan.
1898	Stevenson, C. W.		Estrado de Fero Central do Brasil. . . .	Rio de Janeiro, Brazil, S. A.
1903	Stewart, A.		M. S., Southern	Washington, D. C.
1906	Stewart, A. F.		M. M., Chesapeake & Ohio	Clifton Forge, Va.
1906	Stewart, C. J.		M. M., N. Y. N. H. & H. R. R.	So. Boston, Mass.
1900	Stewart, M. D.		Fitz-Hugh Luther Co.	Hammond, Ind.
1909	Stewart, R. L.		M. M., Chgo., Rock Island & Pacific.	Kansas City, Kan.
1905	Stewart, T. R.		D. M. M., B. & O. R. R.	Baltimore, Md.
1890	Stillman, H.		E. of T., Southern Pacific	Oakland, Cal.
1896	Stocks, W. H.			5851 Indiana ave., Chicago, Ill.
1911	Storey, J. W.		C. D., Central of Georgia Ry.	Savannah, Ga.
1907	Stuart, C. M.		M. M., Philadelphia & Reading	Tamaqua, Pa.
1910	Stubbs, G. W.		Gulf Line Ry.	Ashburn, Ga.
1890	Studer, A. L.			Iola, Kan.
1901	Sullivan, J. J.		G. M. M., Louisville & Nashville	Birmingham, Ala.
1909	Sullivan, T. F.		M. M., San Antonio & Aransas Pass.	Yoakum, Tex.
1891	Summerskill, T. A.			Montreal, Can.
1892	Sumner, Eben T.		M. M., Boston & Maine	E. Cambridge, Mass.
1910	Sumner, Eliot		M. M., Nor. Cent. R. R.	Baltimore, Md.
1899	Suzuki, S.		S. M. P., Imperial Govt. Rys.	Kobe, Japan.
1909	Sweeley, E. H.		G. F. L. R., Long Island	Richmond Hill, L. I., New York City.
1909	Sweetman, E. M.		M. M., Southern	Birmingham, Ala.
1901	Swoyer, H.		Rogers Locomotive Works	Paterson, N. J.
1899	Symington, T. H.			Calvert Building, Baltimore, Md.

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JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1908	Symons, J. E.		D. M. M.. Gulf, Colo. & Santa Fe Ry.	Cleburne, Tex.
1892	Symons, W. E			Postal Tel. Bldg., Chicago, Ill.
1883	Tandy, H.		Supt. Canadian Loco. Works	Kingston, Ont., Can.
1896	Tawse, Robert		S. M. P., D. T. & I. Ry.	Jackson, Ohio.
1893	Taylor, C. M.		S. M. P., Chgo., Rock Island & Pacific	Shawnee, Okla.
1901	Taylor, H. D.		S. M. P. & R. E., Phila. & Reading	Reading, Pa.
1893	Taylor, Wm. H.		M. M., N. Y., Susq. & Western	Stroudsburg, Pa.
1905	Taylor, W. M.		M. M., Thornton & Alexandria	Thornton, Ark.
1905	Temple, C. H.		M. M., Canadian Pacific	Winnipeg, Man.
1904	Terrill, C. H.		M. M., Chesapeake & Ohio	Huntington, W. Va.
1911	Thayer, F. C.		G. R. F. E., Southern Ry	Atlanta, Ga.
1904	Thomas, E.		S. M. P., Central Northern	Tecumen, Arg. Rep., S. A.
1908	Thomas, F. W.		Supervisor of App., A. T. & S. F. Ry.	Topeka, Kan.
1891	Thomas, H. T.		M. M., Detroit & Mackinac	East Tawas, Mich.
1910	Thomas, I. B.		S. M. P., Penna. R. R.	Williamsport, Pa.
1892	Thomas, J. J., Jr.		S. M. P., So. Ry. in Miss.	Mobile, Ala.
1901	Thomas, W. J.		Porto Bello	Canal Zone.
1890	Thompson, C. A.			Morris Park, Long Island, N. Y.
1903	Thompson, E. B.		S. M. P., Chgo., St. Paul, Minn. & Omaha.	St. Paul, Minn.
1896	Thompson, Geo.		S. M. P., Denver, Northwestern & Pac.	Denver, Colo.
1902	Thompson, W. O.		M. C. B., N. Y. Central & H. R. R. R.	Buffalo, N. Y.
1895	Thompson, W. T			32 St. Johns pl., Buffalo, N. Y.
1910	Thomson, S. G.		A. E. M. P., P. & R. Ry.	Reading, Pa.
1902	Thornton, Chas. J.		L. S., United Rys. of Havana	Havana, Cuba.
1883	Thow, Wm.		C. M. E., Government Rys.	Sydney, N. S. W.
1911	Tierney, H. J.		M. E., M. K. & T. Ry.	Parsons, Kan.
1909	Tilton, G. F.		M. M., Mexican Ry.	Orizaba, V. C., Mexico.
1903	Tinker, J. H.		M. M., Chicago & Eastern Illinois	Danville, Ill.
1903	Todd, A. B.		M. M., T. & T. Ry.	Stagg, Cal.
1892	Todd, Louis C.		M. M., Boston & Maine	Charlestown, Mass.
1898	Tollerton, W. J.		A. G. S. M. P., Chicago, R. I. & Pacific.	Chicago, Ill.
1901	Toltz, Max		Manistee & Grand Rapids	St. Paul, Minn.
1903	Torrey, F. A.		G. S. M. P., Chicago, Bur. & Quincy	Chicago, Ill.
1896	Tracy, W. L.		A. S. M., Mo. Pacific	Kansas City, Mo.
1892	Traver, W. H.		Chicago Pneumatic Tool Co.	Chicago. Ill.
1883	Tregelles, Henry		B. M. E., Mitre	544 Buenos Aires, Arg. Rep., S. A.
1908	Tritsch, C. M.		S. M. P., Western Maryland R. R.	Hagerstown, Md.
1903	Trumbull, A. G.		M. S., Erie	Cleveland, Ohio.
1890	Tuggle, S. R.			Houston, Tex.
1903	Tuma, Frank		M. M., Erie	Buffalo, N Y.
1899	Turner, A.		M. M., Lehigh Valley	South Easton, Pa.
1890	Turner, Calvin G.		M. M., Phila., Balt. & Washington	Wilmington, Del.
1906	Turner, J. A.		M. M., C. St. P. M. & O. Ry.	Itasca, Minn.
1886	Turner, J. S.		Pressed Steel Car Co.	24 Broad st., N. Y. City.
1890	*Turner, L. H.*	189	*S. M. P., Pittsburgh & Lake Erie*	*Pittsburgh, Pa.*
1898	Van Alstyne, D.		American Locomotive Co.	New York.
1905	Vanaman, C. D.		M. M., Florida East Coast	St. Augustine, Fla.
1904	*Van Buskirk, H. C.*	172	*S. M. P., Colorado & Southern*	*Denver, Colo.*
1896	Van Cleve, J. R.		M. M., Copper River	Cordova, Alaska.
1904	Van Doren, G. L.		S. S., Central R. R. of New Jersey	Roselle Park, N. J.
1910	Van Valin, H. D.		D. M. M., B. & O. R. R.	Parkersburg, W. Va.
1891	Vauclain, Samuel M.		Baldwin Locomotive Works	Philadelphia, Pa.
1898	*Vaughan, H. H.*	550	*Asst. to V.-P., Canadian Pacific*	*Montreal, Can.*
1892	Vogt, A. S.		M. E., Pennsylvania	Altoona, Pa.

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JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1904	Wagstaff, George		American Arch. Co	30 Church st., New York, N. Y.
1905	Wahlen, John		M. M., Montpelier & Wells River	Montpelier, Vt.
1892	Waitt, A. M			165 Broadway, New York City, N. Y.
1893	Walker, Henry E		Buenos Aires Great Southern	Buenos Ayres, Arg. Rep., S. A.
1908	Wall, G. L		M. E., Lima Loco. & Mach. Co	Lima, Ohio.
1908	Wall, H. S		M. M., Atchison, Topeka & Santa Fe	San Bernardino, Cal.
1904	Wallace, W. G		American Steel Foundries	Chicago, Ill.
1888	Wallis, Phillip			Hotel Roanoke, Roanoke, Va.
1910	Walsh, F. F		M. M., Marshall & East Texas Ry	Marshall, Texas.
1909	Walsh, F. J		Chicago Pneumatic Tool Co	Richmond, Va.
1910	Walsh, Geo. B		G. F., N. Y. C. & H. R. R. R	Corning, N. Y.
1910	Walsh, J. F		M. M., M. & E. T. Ry	Marshall, Tex.
1900	*Walsh, F. O*	32	*M. M., A. & W. P. & W. Ry. of Ala*	*Montgomery, Ala.*
1903	Walsh, J. F		G. S. M. P., Chesapeake & Ohio	Richmond, Va.
1874	Walsh, Thos		M. M., Louisville & Nashville	Howell, Ind.
1908	Walsh, W. F		A. B. Insp., C. & O. Ry	Gordonsville, Va.
1896	Walton, E. A			611 Central st., Franklin, Mass.
1911	*Wardwell, H. F*		*S. P. & E., Chicago & West. Ind. Ry*	*Chicago, Ill.*
1908	Warnock, H. R		G. F. L. D., Monongahela R. R	Brownville, Pa.
1882	Warren, W. B			1619 Pennsylvania ave., St. Louis, Mo.
1910	Warthen, H. J		M. M., Washington Southern Ry	Alexandria, Va.
1909	Warthen, J. O		M. M., Danville & Western	Danville, Va.
1903	Waters, J. J			
1906	Watkins, W. H		M. M., Illinois Central	Water Valley, Miss.
1908	Watson, R. B		Engr. Tests, Erie R. R	Meadville, Pa.
1902	Watson, Samuel		M. M., N. Y. C. & H. R. R. R	Avis, Pa.
1904	Watters, J. H		A. M. M., Georgia	Augusta, Ga.
1883	Watts, Amos H		M. M., Cincinnati Northern	Van Wert, Ohio.
1907	Weisgerber, E. L		M. M., Baltimore & Ohio	Newark, Ohio.
1899	Weist, E. N		M. M., Manistee & North-Eastern	Manistee, Mich.
1909	Weitzel, H		Supt. Shops, Can., Yaqui River & Pacific	Empalme, Sonora, Mex.
1906	Wells, M. E		A. M. M., Wheeling & Lake Erie	Brewster, Ohio.
1911	Werst, C. W		Wks. Supt., Lima Loco. & Mach. Co	Lima, Ohio.
1907	White, Alfred			Dickinson, N. D.
1885	White, A. M		American Locomotive Co	Manchester, N. H.
1894	White, E. T		S. M. P., Baltimore & Ohio	Mt. Clare, Baltimore, Md.
1908	White, J. E		M. M., Louisville & Nashville	Pensacola, Fla.
1901	White, W			225 Ry. Exchange Bldg., Chicago, Ill.
1898	Whyte, F. M		New York Air Brake Co	Watertown, N. Y.
1894	Wiggin, Chas. H		S. M. P., Boston & Maine	Boston, Mass.
1878	Wightman, D. A			Warren, R. I.
1891	Wilcox, W. J		M. M., Las Vegas & Tonopah	Las Vegas, Nev.
1901	Wildin, G. W		M. S., N. Y., New Haven & Hartford	New Haven, Conn.
1896	Williams, Alfred		Paulista Ry. Co	Jundiahy Estado de Sao Paulo, Brazil, S. A.
1905	Williams, C. R		Corning Machine Co	Corning, N. Y.
1891	Williams, E. A			259 Ridgwood ave., Glenridge, N. J.
1910	Williams, E. V			115 Carolina st., Buffalo, N. Y.
1903	Williams, F. W		S. M. P., C. R. I. & G. Ry	Ft. Worth, Tex.
1909	Williams, W. H		M. M., Buffalo, Rochester & Pittsburgh	Salamanca, N. Y.
1905	Willius, Gustav, Jr		Robinson Cary & Sands Co	St. Paul, Minn.
1905	Wilson, Charles		M. M., Lehigh Valley	Wilkesbarre, Pa.
1906	Wilson, D. H., Jr		Elec. Engr., Erie	Meadville, Pa.
1887	Wilson, G. F		P. A., Del., Lack. & Western	New York City.
1901	Wilson, W. H		Asst. to 3d V.-P., Nor. Pac. Ry	St. Paul, Minn.
1900	Wirt, G		M. M., C. C. C. & St. L	Delaware, Ohio.
1910	Woodcock, C. A		M. M., Caguas Tramway	San Juan, Porto Rico.
1903	Woodruff, S. N		M. M., Minn., St. P. & Sault Ste. Marie	Enderlin, N. D.

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JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1903	Worsdell, Wilson		C. M. E., North-Eastern	Gateshead-on-Tyne, Eng.
1901	Wright, R. V		American Engineer	285 N. 20th st., E. Orange, N. J.
1907	Wyman, R. L		M. M., Lehigh & New England	Pen Argyl, Pa.
1907	Yamamoto, Y			No. 2 Gazenbu, Azabu-Ku-Tokio, Japan.
1908	Yeager, Thos		M. M., Illinois Southern	Sparta, Ill.
1903	Yergens, W. F		M. M., Erie	Huntington, Ind.
1896	Yohn, A. E		M. M., H. & B. T. Mtn	Saxton, Pa.
1899	York, F. C		B. A. & Pacific . . .	Estacion Junin, Buenos Ayres, Arg. Rep., S. A.
1911	Yoshino, M		C. M. E., South Manchurian Ry	Darien, South Manchuria.
1902	Young, C. B		M. E., Chicago, Burlington & Quincy	Chicago, Ill.
1908	Young, C. D		A. E. M. P., Penna. Lines West	Pittsburgh, Pa.
1905	Young, R. R		Repr. Southern Iron & Equip. Co	Atlanta, Ga.
1907	Zang, P. C		M. M., N. Y., New Haven & Hartford	New Haven, Conn.
1898	Zerbee, F. J		M. M., C. C. C. & St. L	Bellefontaine, Ohio.

ASSOCIATE MEMBERS.

JOINED.	NAME.	ADDRESS.
1911	Averill, E. A	Amer. Engineer & R. R. Journal, New York City.
1893	Baker, Geo. H	227 Monroe st., Brooklyn, N. Y.
1898	Basford, G. M	Amer. Loco. Co., 30 Church st., New York City.
1898	Bates, E. C	Lock Box 1544, Boston, Mass.
1907	Bell, J. Snowden	149 Broadway, New York City.
1911	Endsley, L. E., Prof	Purdue University, La Fayette, Ind.
1896	Fowler, Geo. L	53 Broadway, New York City.
1907	Fry, Lawford, H	Paris, France.
1895	Goss, W. F. M	University of Illinois, Urbana, Ill.
1889	Hill, John A	505 Pearl st., New York City.
1904	Hodgins, George	114 Liberty st., New York City.
1899	Kneass, Strickland L	Wm. Sellers Co., Ltd., Philadelphia, Pa.
1901	Lane, F. W	537 W. 67th st., Chicago, Ill.
1904	Lanza, Gaetano	Mass. Inst. of Technology, Boston, Mass.
1901	Player, John	American Loco Co., Brooks Works, Dunkirk, N. Y.
1889	Pomeroy, L. R	Care of J. G. White & Co., New York City
1909	Schmidt, E. C	University of Illinois, Urbana, Ill.
1899	Smart, R. A	Oliver Chilled Plow Wks., South Bend, Ind.
1882	Smith, W. A	Manhattan Bldg,. Chicago, Ill.
1899	Street, Clement F	Box 192, Schenectady, N. Y.
1903	Taylor, Jos. W	390 Old Colony Bldg., Chicago, Ill.

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HONORARY MEMBERS.

JOINED.	NAME.		ADDRESS.
1892	Allen, G. S.		Tamaqua, Pa.
1885	Becker, Andrew		New Decatur, Ala.
1879	Cooke, Allen		Danville, Ill.
1869	Coolidge, G. A		Barnard ave., Watertown, Mass.
1870	Cooper, H. L.		Chesterton, Ind.
1876	Cory, Chas. H		Lima, Ohio.
1895	Coster, E. L.	Residence, Irvington-on-Hudson	Broad Exchange Bldg., 25 Broad st., N. Y. City.
1881	Eastman, A. G		Sutton, Que.
1872	Foss, J. M.	Central Vermont	St. Albans, Vt.
1885	Galloway, A		Chief of Police, Los Angeles, Cal.
1883	Gilmore, W. L.		Elkhart, Ind.
1887	Hill, J. W.		Peoria, Ill.
1901	Holtz, David		2015 13th st., Walbrook, Baltimore, Md.
1874	Jeffery, E. T.	Denver & Rio Grande	Denver, Colo.
1868	Johann, Jacob		Springfield, Ill.
1868	Kinsey, J. I.	Lehigh Valley	Easton, Pa.
1878	Maglenn, Jas.	Seaboard Air Line	Raleigh, N. C.
1888	Medway, John		7 Hawthorne ave., Troy, N. Y.
1871	Miles, F. B.	Bement & Miles	Philadelphia, Pa.
1885	Millen, Thos		105 W. 51st st., New York City.
1885	Paxson, L. B.	Philadelphia & Reading	Reading, Pa.
1878	Pilsbury, Amos		Portland, Me.
1874	Place, T. W.		Waterloo, Iowa.
1881	Player, John		319 Franklin ave., River Forest, Ill.
1892	Rettew, C. E		Carbondale, Pa.
1887	Rhodes, Godfrey W		Westbaugh, Pontefract, Yorkshire, England.
1869	Richards, George		14 Auburn st., Roxbury, Mass.
1870	Robinson, W. A.		Hamilton, Ont.
1874	Schlacks, Henry		1086 Sheridan Road, Chicago, Ill.
1885	Sedgwick, E. V.		Franklin, Pa.
1869	Sellers, Morris		Western Union Bldg., Chicago, Ill.
1869	Setchel, J. H.		Cuba, N. Y.
1891	Sheer, J. M		514 7th st., East St. Louis, Ill.
1888	Sheppard, F. L.	Pennsylvania	Altoona, Pa.
1868	Sprague, H. N		Jamestown, N. Y.
1875	Strode, Jas.		Elmira, N. Y.
1883	Sullivan, A. W.	Illinois Central	Chicago, Ill.
1883	Thomas, W. H		4230 Spruce st., Philadelphia, Pa.
1870	Towne, H. A		54 S. 3d st., Minneapolis, Minn.
1883	Twombly, F. M		5 Westville st., Dorchester, Mass.
1868	Wells, Reuben		Paterson, N. J.

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PROCEEDINGS

The President, C. E. Fuller, Assistant General Manager of the Union Pacific Railroad, called the meeting to order at 9:30 o'clock.

THE PRESIDENT: We will be glad to have the President, Past Presidents and members of the Executive Committee of the Master Car Builders' Association, and also of the Master Mechanics' Association, come forward and take chairs upon the platform.

THE PRESIDENT: If you will kindly rise, the Rev. Newton W. Cadwell, pastor of the Olivet Presbyterian Church, of Atlantic City, will open the exercises with prayer.

Prayer by Reverend Cadwell.

THE PRESIDENT: We have with us this morning a gentleman who needs no introduction, and I am happy to say that he has made his word good that he would have the sun shining for us this morning. I present His Honor, Mayor Franklin P. Stoy.

MR. FRANKLIN P. STOY: Mr. President and members of the Association: I have made promises for many years past to this Association, and in almost every instance I think I have made good. Certainly this is one of the times in our lives when we feel that the Association of Car Builders is one of the institutions that everybody who visits Atlantic City hopes to find here because they know they will have a good time. It is a little of a hardship this morning for me to get here so early. After closing up business last evening and getting to sleep rather late, it is rather hard to get up, eat breakfast, and be on hand to follow the band at 9 o'clock in the morning. However, the followers of this Asso-

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ciation, the faithful ones, seem always to be on deck and with a smiling countenance.

I am expected to extend to you the courtesies that I have always extended, but, like other affairs of life, they grow in numbers. However, there is but one thing to do: that is, to meet in the same pleasant manner, in the same delightful atmosphere, and conduct business with the energy with which Americans always go into affairs. It is, therefore, a pleasant duty for me to again meet with you and to say that Atlantic City is handing out to you whatever is necessary for the comfort and pleasure of the convention. I trust that your stay here will be one of profit to you as in the past. I assure you that Atlantic City wishes you a lovely time, and expects you to come here again and again. In choosing your place for the next convention, we want you to remember that the same latch string is hanging on the outside, and we want you to choose Atlantic City as your place of meeting as long as we can satisfy you in every respect. I thank you. [Applause.]

THE PRESIDENT: Your Honor, you remind me of Cain. The only difference is that you have got a little ahead of him. You have welcomed the Car Builders this morning, and I presume that when they meet for their convention next week you will welcome the Master Mechanics. [Laughter and applause.] Now I will ask Mr. Bentley to respond to Mayor Stoy, on behalf of the Association.

MR. H. T. BENTLEY (C. & N. W. Ry.): The members of this Association wish to thank you, Mayor Stoy, for the kind greeting you have accorded to us. A convention without Mayor Stoy would be like Atlantic City without the sea, and we all hope that Mayor Stoy may continue to welcome us as long as we make Atlantic City our headquarters. Mr. Fuller, the President, mentioned the little mistake that the Mayor made in addressing us. Well, I think perhaps that came very natural. I know sometimes when I have been up until 3 or 4 o'clock in the morning I have fallen into the error of blaming it on the Car Builders [laughter]. I will say this for Mayor Stoy: Whenever he makes a promise he generally makes good. He promised us good weather for this convention, and from the indications this morning I think he is living up to his record for veracity in that respect. It seems to

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me, though, that the privileges this year have been somewhat curtailed. Some of my friends told me they were in a quandary and did not know what to do; but last year they got a card giving us police protection so that if at any time they got into trouble they would be all right, but this year the Atlantic City officials have not distributed any such cards. Of course, that may be due to some lack of decorum on the part of some of the members last year, and, perhaps, the Mayor did not want to furnish them this year.

I wish to thank the Mayor on behalf of the Association for his greeting. I also desire to extend the thanks of the Association to Rev. Dr. Cadwell for his splendid prayer, and we hope that he, too, may be with us on a number of similar occasions. [Applause.]

President Fuller then delivered his annual address as follows:

ADDRESS OF PRESIDENT C. E. FULLER.

On this, the occasion of the opening exercises of the forty-fourth annual convention of the American Railway Master Mechanics' Association, it is my privilege and sincere pleasure to extend to you a hearty welcome. It is an especial pleasure that we are permitted to gather for the sixth time in this beautiful spot, so happily called the "Venice of America." Its hospitality has been proven and has left only the most pleasant recollections.

I will not take up your time in dwelling upon the work of the Association in the past, but will confine my remarks to the events of the year and to some of the problems which confront us.

The American Railway Master Mechanics' Association stands for progress, as evidenced by its growth and accomplishments since its inception; and at our annual conventions, or birthday celebrations, as we might call them, we review the work of the past and look forward to the future with brighter hopes and renewed vigor.

The year 1910-1911 has been a memorable one in so far as it relates to government legislation affecting the railways in general, and the mechanical department in particular. During this period federal laws have been enacted regulating safety appliances for railway equipment; also laws regulating the inspection and care of locomotive boilers. In some States there has been additional legislation, the full crew and caboose bills and headlight bills, while in addition to the federal legislation there has been in some parts of the East state legislation with regard to boiler inspection. In view of the federal and state legislation on the same matters, it would

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seem every possible effort should be made to have the state laws either withdrawn or amended to agree with the government legislation.

In the matter of safety appliances, your committee, in conjunction with the Master Car Builders' Association, has had this work in hand and has given a great deal of time to it, conferring with the government officials as well as representatives of the railway employees, and a set of rules has been formulated covering the requirements.

In my opinion, this Association should insist on the Interstate Commerce Commission furnishing necessary drawings, specifying in detail the location for safety appliances.

Your committee also gave considerable time and work to the boiler bill, and, in conference with the government officials, arrived at rules governing the same.

As the work of your special committee on the Safety Appliance and Boiler bills has now been completed, and as both of these have to do exclusively with technical matters which can properly be handled by mechanical men, it would seem the future work in connection with these matters should be taken over by the Association, and I would recommend the appointment of a committee to handle it. In this connection I can not too strongly recommend that the members of this Association conform promptly to the requirements of the Safety Appliance and Boiler Bills, which will indicate to the commission that the railways of America are ready to comply with the law if the requirements are clearly known.

It also appears to me that the requirements of the Safety Appliance act, as well as the Boiler bill, should be embodied in and adopted as the standard of this Association.

In view of past legislation on matters pertaining particularly to the mechanical department, it would seem to me that the policy and work of this Association should be more clearly outlined than ever before.

Our experience emphasizes the necessity for looking forward and taking such steps toward uniformity as will enable this Association to take the initiative in these matters. I believe this is an opportune time for members of the Association to get away from a great many of their personal opinions and get together and agree on the best standards and practices to a greater extent than ever before, and, having arrived at such standards, they should be followed. Uniformity and unity should be the keynote of our future endeavors. The present conditions, so far as railway operation is concerned, have brought out in the columns of the various technical journals and elsewhere the thoughts of many master minds; and, while the trend of my remarks may not be along entirely original lines, I have selected such thoughts as seem to me to be the most pertinent to our needs.

In reviewing these articles and considering the situation and problems to be met, the small word "unity" stands out above all others. Unity is the strength and support of any organization. The framers of the Constitution of the great country realized it as we must realize it. We talk of scientific management and efficiency, but we must remember that there is

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nothing truer than that much-quoted, but golden, sentence, "United we stand; divided we fall." Unity means harmony and coöperation, and by united effort will the desired results be obtained.

With united strength we can lead, not follow. This Association stands alone and unique — the strongest mechanical organization in the world; yet our work is not being felt as it should be felt, owing to the fact that some of the individual members do not follow and carry out the recommendations of the Association. This Association for years has had committees on the most important matters, and the work should not become lost or buried.

It is not my intention to criticize, and I hope my remarks will not be so taken, as this is far from my thought or purpose, but I am very much afraid that our work is to a certain extent lost sight of, due to the fact that the Association has not taken advantage as it should of that which has been done, and has not adopted recommended practices, nor have such practices been printed in the Proceedings, as they should be, from year to year.

Recent discussion and events have brought rather prominently to public view the discussion of efficiency and economy in railway operation, but it is far from a new subject so far as those engaged in railway work are concerned. As railway officials, efficiency and economy have been our constant watchwords. Much has been done. The installation of the most modern rolling stock and shop equipment has brought about greatly increased efficiency in railway operation. The commercial feature of our operations has been watched, with consequent increased efficiency in shop management.

Publicity has not until recent years entered very largely into railway operations, and the public has not been fully informed of the efforts and accomplishments of the railways along the lines of efficiency and economy. Railways have a very deep interest in having the public correctly understand the achievements which have been made. Every published statement, reflecting credit on the railways, whether relating to their good intentions or their able management, strengthens them in the public esteem and tends to promote a calm and wise solution of the problems of governmental regulation. There is among us no disposition to evade discussion of our efficiency.

So far as the mechanical department is concerned, our efforts have not been sufficiently brought to the light of public recognition. We have been content with the satisfaction which comes from appreciation expressed by those best in position to judge. The operation of American railways has been praised by the highest authorities abroad as the most efficient and economical in the world. We have spent our lives in learning all we could from any quarter whatsoever which might be useful in promoting efficiency and increasing economy.

What is the purpose and significance of this convention? This is the forty-fourth annual meeting of the American Railway Master Mechanics'

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Association. During a span of nearly half a century the railway companies of this country have delegated the responsible heads of their mechanical departments to attend these annual meetings. Here, each of us in turn, gives his best thought and the result of his own experience to the others. Here the standard of efficiency and economy in the performance of every function incident to the manufacture and maintenance of cars and locomotives has been advanced by comparison of experience and of views. Here we have had the suggestions of men not our members. It has mattered not to us what was the source of help.

The public should know, that of all the enterprises of the country, no other approaches the railways in systematic and persistent study of efficiency and economy.

In addition to this mechanical organization, the officials connected with the maintenance of way have their engineering association, which meets annually, and whose purposes are similar to ours. Our foremen of the various branches of the work have their organizations, meeting annually to exchange ideas and improve the efficiency of their members.

The entire territory of the United States is divided into sections, each having its territorial railway clubs and organizations for the furtherance of research and efficiency along specific lines. The existence of these organizations, comprising the efficient managers and department heads of the railways, all endeavoring to systematize and improve operating methods, is cited simply as additional evidence of what the railways are doing to bring about improved methods and increased efficiency.

From the foregoing you will readily appreciate there is very much that the American Railway Master Mechanics' Association can do along the lines indicated.

I see no reason why this Association should not have, as a part of its recommended practices, mechanical plans for large and small terminals, units embodying the best practices, so that if conditions are such that these plans in their entirety are not feasible or practicable, it will be possible to take therefrom the best available features under which shop layouts can be designed. There are a good many of the railways that do not employ large and expensive engineering forces, and such plans would be of infinite value to such members.

A very pertinent subject in connection with the matter of increased efficiency, to my mind, is the education of our apprentices; in fact, of all our employees. By what better method can we hope to increase our efficiency than by setting a high standard for the young men we are educating, from whom we must be able to draw our foremen and shop managers? Progress has been made by some of the individual lines not only in the way of educating apprentices, but also giving other employees similar advantages by instituting plans of broad scope, with educational bureaus open to all employees. It is my opinion that, in line with these efforts, our Association should adopt a recommended apprentice system for appren-

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tices to the various trades, as well as for the technical graduates, commonly called "special apprentices."

On the recommendation of my predecessor, a committee was appointed in connection with the establishment of a permanent technical bureau within our Association. Such a bureau can not help but be a valuable asset of this Association, and I can not too strongly endorse the wisdom of this plan, which I hope will be carried out at an early day. I have indicated the work which has been accomplished by the special committee which conferred with the government officials in the matter of safety appliances and the boiler bill. This simply illustrates what can be done and the value of a centralized bureau to handle subjects which are of a mechanical nature is, it would seem to me, very apparent.

By invitation, this Association had a representative in attendance at the annual meeting of the Conservation Congress. The aim and work of this congress are something in which every member of this Association is vitally interested, and I believe it should have our coöperation and support in every way possible.

The question of consolidating this Association with our sister Association, the Master Car Builders', has been discussed for some years, and there has been considerable agitation of the matter for the last three years. Committees have been appointed, but up to the present time the proposition has not been settled. It has been the opinion of a great many of the members that the consolidation of the two associations was not feasible and practicable, and I leaned to this opinion, but the more I have studied the subject the more I have become impressed with the idea that the union of these two associations will enable us to carry on the work in a far more satisfactory manner. Those of us who have worked in both associations realize what an extra amount of work and time two associations mean for the individual members, and I personally feel the time is ripe for this consolidation or union of the two associations, and I believe the committee should be instructed to perfect plans so that this consolidation can be accomplished as quickly as possible.

There are a number of important matters confronting railways at this time which should receive our earnest attention and coöperation. We have under consideration and have had committees appointed to investigate during the past year some fifteen subjects comprising important mechanical problems of to-day, and I trust that the reports of the committees will be carefully analyzed and freely discussed to obtain the full benefit of the able work which has been done.

I would call particular attention to the report of the Committee on Design and Construction of Locomotive Boilers. In my opinion, this Association should arrive at such standards for boiler design as will be adopted and followed by all members.

Before closing, it seems fitting that mention should be made of the efforts of the Railway Supply Manufacturers' Association, which is entitled to a hearty vote of thanks for its magnificent display and the opportunity

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afforded members of this Association to inspect the many new machines and appliances. Gathered about these conventions, there has grown up, year by year, this imposing exhibit, with many miles of mechanical displays representing the most complete exhibit of its kind to be found anywhere in the world. Immediately accessible are inventors and designers ready and willing to discuss the merits of their devices. Our sessions are so scheduled that several daylight hours every day can be devoted by the delegates to the study of the very latest suggestions in the way of modern equipment and appliances by which we are enabled to bring about increased efficiency and economy. I desire to urge on every attendant at this convention that he take full advantage of this opportunity.

In conclusion, I wish to express my sincere appreciation of the coöperation and assistance of the officers of the Association, committees and individuals who have assisted in preparing reports and otherwise rendered efficient service in the work of the Association. To you all I extend my heartfelt thanks.

[Applause.]

The following members registered their names:

Allan, Arthur.
Appler, A. B.
Arden, D. D.
Arp, W. C.
Atkinson, R.
Ayers, A. R.
Baker, Geo. H.
Bartlett, Henry.
Basford, Geo. M.
Bawden, Wm.
Bayley, J. J.
Bean, S. L.
Bell, R. W.
Bennett, W. H.
Best, W. N.
Bingaman, Charles A.
Blunt, James G.
Booth, J. K.
Booth, J. S.
Boughton, Wm.
Bowden, J. F.
Bowles, C. K.
Boyden, N. N.
Brangs, P. H.
Brown, M. G.
Burk, C. H.
Burton, T. L.
Bussing, G. H.
Butler, F. A.
Chambers, C. E.
Chambers, J. S.
Chidley, Joseph.
Christopher, Jacob.
Clark, F. H.
Cleaver, F. C.
Cole, F. J.
Combs, W. B.
Cooper, F. R.
Cory, C. H.
Cox, R. G.
Cromwell, Oliver C.
Cross, C. W.
Cullinan, John.
Curtis, Theo. H.
Dalton, Wm.
Davis, John E.
Davis, Joseph M.
Deems, J. F.
Deeter, D. H.
Dickerson, S. K.
Diehr, C. P.
Dillon, S. J.
Dooley, Wm. H.
Duffey, G. J.
Dunham, W. E.
Dunn, Jas. F.
Durborow, R. N.
Eden, E. S.
Edmonds, Geo. S.
Elliott, J. B.
Emory, J. B.
Endsley, Prof. L. E.
Enright, J. F.
Fetner, W. H.
Ferguson, L. B.
Fitzsimmons, E. S.
Flavin, F. J.
Fowler, Geo. L.
Franey, M. D.
Fulmor, John H.
Gardner, Henry.
Garstang, Wm.
Gentry, T. W.
Gillis, H. A.
Goodrich, Max.
Gordon, H. D.
Graburn, A. L.
Green, Herbert.
Greenwood, B. E.
Greenwood, H. F.
Grimshaw, F. G.
Haig, M. H.
Hainen, J.
Hale, H. H.

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Hamilton, Taber.
Hammett, Philip M.
Harrigan, John.
Harrigan, P. J.
Harrington, H. H.
Harris, C. M.
Haug, Harry.
Hawkins, B. H.
Hawkins, R. D.
Hayes, W. C.
Hayward, H. S.
Hedley, F.
Henry, J. M.
Henry, W. C. A.
Herr, E. E.
Hess, Geo. F.
Hildreth, Fred F.
Hill, Rufus.
Hill, W. H.
Hodgins, Geo. S.
Hoffman, C. M.
Hoffmaster, F. S.
Horsey, A. W.
Howson, G. N.
Huber, H. G.
Hunter, H. S.
Jackson, H. D.
Jackson, O. S.
Jacobs, Henry W.
James, Charles.
James, E. T.
James, J. M.
Jaynes, R. T.
Johnson, Frank.
Johnson, L. R.
Joughins, G. R.
Kadie, C. H.
Keenan, C. E.
Keegan, Jas. E.
Keiser, C. B.
Kellogg, W. L.
Kells, Willard.
Kendig, R. B.
Kiesel, W. F.
Kinney, C. D.
Kinney, M. A.
Kirkpatrick, James.
Kneass, Strickland.
Knight, W. Edward.
Kyle, C.
Langton, Geo. H.
Lovell, Alfred.
MacBain, D. R.
McGill, A. M.
McGuire, J. J.
McIlvaine, C. L.
MacKenzie, John.
McLean, J. E.
McNaughton, Jas.
McNulty, F. M.
McPherson, T. J.
Macbeth, H. A.
Manning, James A.
Mathis, J. E.
Maxfield, H. H.
May, H. C.
May, Walter.
Mean, E. G.
Mechling, J. E.
Meister, C. L.
Michael, J. B.
Miller, E. A.
Milliken, Jas.
Minshull, P. H.
Moler, A. L.
Moll, George.
Monkhouse, H.
Montgomery, Wm.
Moriarity, G. A.
Mowery, J. N.
Murray, F. H.
Needham, H. S.
Newhouse, John F.
Noble, L. C.
O'Hearne, John E.
Osborne, H.
Oviatt, H. C.
Owens, W. H.
Page, C. N.
Passmore, H. E.
Patterson, Robert.
Paxton, Thomas.
Pearce, J. S.
Perrine, W. M.
Pffafflin, Louis.
Pilcher, John A.
Plank, P. D.
Poole, A. J.
Prendergast, A. P.
Purvis, T. B., Jr.
Quereau, C. H.
Quigley, Joseph.
Reagan, Frank H.
Redding, D. J.
Reid, W. L.
Reynolds, O. H.
Rhodes, L. B.
Riegel, S. S.
Riley, Geo. N.
Rink, Geo. W.
Robb, J. M.
Robertson, D. D.
Rogers, Robert Hunter.
Rollings, E. O.
Rumney, Thos.
Ryan, J. J.
Schlafge, Wm.
Schmidt, Prof. E. C.
Sechrist, T. O.
Seddon, C. W.
Shea, R. T.
Sheahan, J. F.
Shelby, C. K.
Shepard, L. A.
Sinclair, Angus.
Sinnott, W.
Slayton, C. E.
Slayton, F. T.
Smith, C. B.
Smith, Daniel A.
Smith, H. E.
Smock, F. A.
Sneck, Harry.
Snell, E. J.
Sprowl, N. E.
Staley, H. F.
Stewart, A.
Stewart, A. F.

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Stewart, Thos. R.
Stuart, Charles M.
Stubbs, G. W.
Sumner, Eben T.
Sweeley, E. H.
Schroyer, H.
Tawse, Robt.
Taylor, Wm. H.
Thomas, H. T.
Thomas, I. B.
Thomas, W. H.
Thomson, Samuel G.
Trumbull, A. G.
Tuma, Frank.
Turner, Calvin G.
Van Buskirk, H. C.
Van Doren, G. L.
Van Valin, H. D.
Wagstaff, Geo.
Walsh, Frank J.
Wardwell, H. F.
Warnock, Harry R.
Warthen, H. J.
Watson, R. B.
Watters, J. H.
Watts, A. H.
Wells, M. E.
Wells, Reuben.
Whyte, F. M.
Wildin, G. W.
Williams, W. H.
Wilson, Charles.
Wirt, G.
Wood, L. L.
Wright, R. V.
Wyman, R. L.
Young, C. B.
Young, Charles D.

THE PRESIDENT: We will now take an intermission for five minutes to allow those who care to retire to do so, but we will be glad to have as many remain as desire.

The next order of business is the action on the minutes of the last meeting. They have all been published, and if there is no desire to have them read, a motion to accept them will be in order.

On motion, the minutes were accepted.

THE PRESIDENT: The next order of business is the report of the Secretary and Treasurer.

Secretary Taylor presented his report, as follows:

SECRETARY'S REPORT.

To the President and Executive Committee of the American Railway Master Mechanics' Association:

In accordance with our usual custom at the annual convention, I append herewith statements showing the membership of the Association and reports and expenditures during the year just closed:

ACTIVE MEMBERSHIP.

Membership, June, 1910		952
Transferred to honorary membership	6	
Deaths	11	
Resignations	13	
Dropped, nonpayment of dues and mail returned	1	
	—	31
		921

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New members during the year	78	
Reinstated	1	
	—	79
Total		1,000

ASSOCIATE MEMBERSHIP.

Membership, June, 1910	20
Total	20

HONORARY MEMBERSHIP.

Membership, June, 1910	37
Transferred from active	6
Total	43

TOTAL MEMBERSHIP.

Active	1,000
Associate	20
Honorary	43
Total	1,063

At the convention of 1910, Messrs. C. E. Rettew, Thos. Millen, W. L. Gilmore, J. W. Hill, E. M. Roberts and E. V. Sedgwick were transferred to honorary membership.

During the year the following resignations were received:

Active Members — H. Pollitt, W. F. Dixon, M. Yoshino, W. H. Russell, T. McNabb, H. Stillman, M. H. Wickhorst, A. E. Mitchell, G. E. Parks, B. Warren, E. M. Herr, G. A. Ferguson and D. W. Ford.

The following deaths have been recorded:

Active Members — D. F. Van Ripper, H. H. Johnson, J. B. Gannon, A. J. Dunn, David Brown, Wm. Buchanan, H. S. Bryan, G. J. DeVilbiss, P. G. Thomas, J. Piccioli and S. K. Hatah.

The following names have been taken from the list of members on account of non-payment of dues and mail returned:

T. R. Stewart.

The following is a list of new members during the year:

C. G. Arthur, M. M., Southern Ry., Columbia, S. C.
W. H. Dunlap, M. M., L. & N. R. R., Covington, Ky.
Frank Johnson, M. M., Southern Ry., Sheffield, Ala.
C. H. Kadie, M. M., Southern Ry., Alexandria, Va.
L. L. Dawson, S. M. P., Ft. W. & D. C. Ry., Childress, Tex.
L. K. Smith, Asst. M. M., Wabash R. R., Moberly, Mo.

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C. B. Keiser, M. M., Penna. R. R., New York City.
M. G. Brown, M. M., G. & S. I. R. R., Gulfport, Miss.
M. W. Hassett, M. M., N. Y. C. R. R., E. Buffalo, N. Y.
J. D. Maxwell, M. M., L. & N. R. R., Mobile, Ala.
A. A. McGregor, M. M., L. & N. R. R., Etowah, Tenn.
B. R. Moore, M. M., Miss. Cent. R. R., Hattiesburg, Miss.
Harry Sneck, M. M., B. R. & P. Ry., E. Salamanca, N. Y.
D. E. Fitzgerald, A. S. M. P., St. L. & S. F. R. R., Springfield, Mo.
Frank Burns, M. M., St. L. & S. F. R. R., Monett, Mo.
E. V. Williams, Gen'l Foreman, N. Y. C. R. R., Avis, Pa.
J. K. Booth, G. F., B. & L. E. R. R., Greenville, Pa.
W. M. Perrine, M. M., C. R. R. of N. J., Jersey City, N. J.
H. W. Martin, Supt., Mt. J. K. & R. Ry., Kushequa, Pa.
Geo. Durham, M. M., L. & N. R. R., Louisville, Ky.
H. L. Roth, G. F., C. N. O. & T. P. Ry., Ludlow, Ky.
H. B. MacFarland, Engr. Tests, A. T. & S. F. Ry., Topeka, Kan.
D. D. Robertson, M. M., Lehigh Valley Ry., Wilkesbarre, Pa.
J. H. Painter, S. S., A. C. L. R. R., So. Rocky Mount, N. C.
W. S. Jackson, G. F., L. S. & M. S. Ry., Ashtabula, Ohio.
Wm. Gill, M. M., Iowa Cent. R. R., Marshalltown, Iowa.
J. D. Maupin, M. M., T. & B. V. Ry., Teague, Tex.
H. E. Smith, Chemist, L. S. & M. S. Ry., Collinwood, Ohio.
R. G. Cox, M. M., V. & S. W. Ry., Bristol, Va., Tenn.
G. C. Bornefeld, M. M., United Rys. of Havana, Cienaga, Havana, Cuba.
H. J. Tierney, M. E., M. K. & T. Ry., Parsons, Kan.
J. W. Storey, C. D., Cent. of Ga. Ry., Savannah, Ga.
F. C. Thayer, G. R. F. of E., So. Ry., Atlanta, Ga.
C. D. Kinney, M. M., K. & M. Ry., Hobson, Ohio.
W. P. Carroll, M. M., N. Y. C. R. R., Rochester, N. Y.
E. S. Eden, M. M., Cent. New Eng. R. R., Hartford, Conn.
P. J. Meade, G. F., A. C. L. R. R., Jacksonville, Fla.
H. S. Needham, A. E. M. P., Penna. Lines, Columbus, Ohio.
C. F. Gregory, M. M., Manufacturers R. R., St. Louis, Mo.
F. C. Reed, M. M., Iron Mtn. R. R., McGehee, Ark.
G. J. Duffy, M. M., L. E. & W. R. R., Lima, Ohio.
E. J. Snell, M. M., N. Y. C. & H. R. R. R., Corning, N. Y.
F. W. Rhuark, M. M., B. & O. R. R., Lorain, Ohio.
C. N. Goodall, Mgr., Robt. Stephenson & Co., Darlington, Eng.
J. Cole, M. M., Vera Cruz Term. Ry., Vera Cruz, Mex.
J. L. Meahan, M. M., Ashland Coal & Iron Ry., Ashland, Ky.
G. M. Crownover, M. M., C. G. W. Ry., Oelwein, Iowa.
C. H. Spengler, M. M., B. A. & P. Ry., Anaconda, Mont.
Jas. Markey, M. M., G. T. Ry., Toronto, Ont., Can.
J. C. Ramage, Supt. Tests, So. Ry., Alexandria, Va.
J. W. Brewer, M. M., B. & O. R. R., Baltimore, Md.

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W. D. Bunker, M. M., C. & W. Ry., Pueblo, Colo.
M. H. Haig, M. E., A. T. & S. F. Ry., Topeka, Kan.
J. M. Lynch, M. M., Honduras Ry., Puerto Cortez, Honduras.
C. A. Woodcock, Supt. Term., Porto Rico Power & Light Co., San Juan, Porto Rico.
H. F. Wardwell, Supt. P. & E., C. & W. I. R. R., Chicago, Ill.
J. L. Larallee, A. M. M., Nat'l R. R. of Mexico, Cardenas, S. L. P., Mex.
J. M. Burley, M. M., P. & I. N. R. R., Weiser, Idaho.
W. F. Keisel, Jr., A. M. E., Penna. R. R., Altoona, Pa.
J. C. Mengel, M. M., Penna. R. R., Philadelphia, Pa.
Geo. Ridgway, Asst. Loco. Supt., Dublin & Southeast. Ry., Dublin, Ireland.
C. B. Hathaway, Dist. For., K. C. S. Ry., Mena, Ark.
J. Davis, M. M., Penna. R. R., Harrisburg, Pa.
W. H. Bennett, M. M., Penna. R. R., Juniata, Pa.
I. B. Thomas, M. M., Penna. R. R., Altoona, Pa.
G. S. Allen, M. M., Penna. R. R., Oil City, Pa.
F. J. Walsh, M. M., M. & E. T. Ry., Marshall, Tex.
C. H. Potts, M. M., Penna. R. R., Renova, Pa.
J. M. Henry, M. M., Penna. R. R., Sunbury, Pa.
C. K. Shelby, M. M., Nor. Cent. Ry., Elmira, N. Y.
Eliot Sumner, M. M., Nor. Cent. Ry., Baltimore, Md.
S. G. Thomson, A. E. M. P., P. & R. Ry., Reading, Pa.
Wm. Elmer, M. M., Penna. R. R., Pittsburgh, Pa.
M. A. Malloy, M. M., Penna. R. R., So. Pittsburgh, Pa.
J. M. James, M. M., Penna. R. R., Olean, N. Y.
Jno. Sibbald, M. M., Fonda, Johnstown & Gloversville Ry., Gloversville, N. Y.
C. B. Nelson, A. M. M., L. S. & M. S. Ry., Elkhart, Ind.

REINSTATED.

R. Atkinson, 633 N. Seventeenth street, Philadelphia, Pa.

RECEIPTS.

To dues collected from members	$4,306.00
" sale of Proceedings	1,123.77
" interest on bank balance	7.13
" Ryerson Scholarship	600.00
	$6,036.90

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EXPENSES.

Paid	exchange	$ 19.40
"	expenses, 1910 convention	65.35
"	stamps	419.50
"	office supplies	143.86
"	printing	2,669.96
"	expenses committees	44.75
"	blue-prints	25.00
"	salary	1,500.00
"	zinc cuts, etc	93.93
"	Ryerson	500.00
"	corrections on checks	15.00
"	expenses	25.11
"	telegrams	1.11
"	refund for dues	10.00
"	reporting convention	176.60
"	office rent	223.20
"	surety bonds	8.00
"	balance to Treasurer	96.13
		$6,036.90

The bills against the Association have all been paid, except for several reports which were received after the books were closed.

A statement showing the members in arrears for dues and the amount thereof is appended for the information of the members, amounting to $1,530.

A detailed statement of the dues collected from the members during the year is appended and made part of the report.

Jos. W. Taylor,
Secretary.

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DETAILED STATEMENT OF DUES COLLECTED FROM MEMBERS.

1910.		
June 11	P. J. Hickey....	$ 15.00
" 11	H. C. May.....	5.00
" 11	R. L. Stewart..	5.00
" 11	E. H. Gorrey...	1.00
" 11	C. G. Desmond.	5.00
" 11	A. B. Adams...	5.00
" 11	Wm. Kelly	10.00
" 11	T. W. Gentry..	10.00
" 11	D. D. Robertson	5.00
" 11	J. H. Painter...	5.00
" 11	H. D. Roth.....	5.00
" 11	Henry Hardie..	5.00
" 18	C. W. Allen....	5.00
" 18	W. C. Arp.....	5.00
" 18	W. G. Black...	5.00
" 19	T. F. Barton...	5.00
" 19	S. L. Bean.....	10.00
" 19	H. T. Bentley..	5.00
" 20	G. H. Baker....	5.00
" 20	J. R. Bissett....	5.00
" 22	Wm. Boughton.	5.00
" 22	J. O. Bradeen..	5.00
" 13	David Brown...	5.00
" 13	A. Buchanan ...	5.00
" 22	C. E. Chambers.	5.00
" 17	E. G. Chenoweth	5.00
" 20	F. J. Cole.....	5.00
" 20	J. J. Connolly..	5.00
" 20	O. C. Cromwell.	5.00
" 19	C. P. Diehr....	10.00
" 20	D. H. Deeter...	5.00
" 20	S. J. Delaney...	5.00
" 17	Geo. Durham ..	5.00
" 17	J. B. Elliott....	10.00
" 17	J. T. Flavin....	5.00
" 17	J. H. Fulmore..	5.00
" 17	C. E. Gossett...	5.00
" 20	W. H. Foster..	5.00
" 20	B. E. Greenwood.	5.00
" 20	E. G. Gross....	5.00
Carried forward		$ 231.00

Brought forward		$ 231.00
June 18	Geo. Gurry	5.00
" 18	H. Haug	5.00
" 21	E. E. Herr.....	5.00
" 21	Jno. Hill	5.00
" 21	W. H. Hill.....	5.00
" 18	C. H. Hogan...	5.00
" 18	A. W. Horsey..	5.00
" 18	G. S. Hunter...	5.00
" 18	Chas. James ...	5.00
" 18	W. L. Kellogg..	5.00
" 17	J. B. Kilpatrick.	5.00
" 17	R. F. Kilpatrick.	5.00
" 17	M. A. Kinney..	5.00
" 18	W. H. Kinney..	5.00
" 20	C. Kyle	5.00
" 20	T. C. Lancaster.	5.00
" 20	C. W. Lee.....	5.00
" 17	D. R. MacBain.	5.00
" 20	M. J. McCarthy.	5.00
" 18	A. M. McGill..	10.00
" 18	A. A. McGregor	5.00
" 18	G. A. Miller....	5.00
" 18	P. H. Minshull.	5.00
" 22	J. D. Maxwell..	5.00
" 20	C. J. Mellin....	5.00
" 20	J. H. Mills.....	5.00
" 20	Geo. Moll	5.00
" 20	S. W. Mullinix.	5.00
" 20	J. F. Newhouse.	5.00
" 20	L. Pfafflin	5.00
" 18	C. Phillips	5.00
" 18	M. J. Powers..	5.00
" 18	Jos. Roberts ...	5.00
" 18	H. W. Ridgway	5.00
" 18	C. M. Stuart....	5.00
" 19	L. A. Shepard..	5.00
" 19	F. C. Smith....	10.00
" 19	H. Swoyer	10.00
" 20	H. G. Reid.....	5.00
" 20	T. O. Secrist...	5.00
Carried forward		$ 446.00

Digitized by Google

	Brought forward	$	446.00
June	20	N. E. Sprowl...	5.00
"	20	G. W. Stubbs...	5.00
"	20	C. M. Terrell...	5.00
"	20	J. J. Thomas...	5.00
"	13	C. H. Rae.....	5.00
"	15	E. O. Rollings..	5.00
"	15	H. F. Staley....	5.00
"	16	Jno. Tonge	5.00
"	16	O. H. Reynolds.	5.00
"	17	T. F. Sullivan..	5.00
"	22	D. A. Smith....	5.00
"	22	E. J. Smith.....	5.00
"	22	E. T. Sumner..	5.00
"	22	G. L. Van Doran.	5.00
"	22	H. R. Warnock.	5.00
"	14	W. H. Dunlap.	5.00
"	16	J. J. Waters....	5.00
"	19	J. K. Booth.....	5.00
"	20	W. H. Williams	5.00
"	20	Frank Burns ..	5.00
"	20	D. E. Fitzgerald	5.00
"	18	B. R. Moore....	5.00
"	19	E. V. Williams.	5.00
"	22	G. W. Wildin...	5.00
"	22	Chas. Wilson ..	5.00
"	27	E. N. Weist....	5.00
"	27	W. H. Nuttall..	5.00
"	27	M. Parra	5.00
"	27	G. S. Tilton....	5.00
"	27	C. H. Burk.....	5.00
"	27	E. E. Machovec.	5.00
"	27	I. M. Malone...	15.00
"	27	M. C. Dinkel...	5.00
"	27	W. S. Grandy..	5.00
"	27	W. J. Hill.....	10.00
"	27	G. O. Hammond	15.00
"	27	Wm. Henry ...	5.00
"	27	F. Tuma	5.00
"	27	A. Dinan	5.00
"	27	H. Ashton	5.00
"	27	W. M. Taylor..	10.00
"	27	H. S. Wall.....	5.00
"	27	J. W. Taylor...	5.00
	Carried forward	$	691.00

	Brought forward	$	691.00
June	27	H. W. Martin..	5.00
"	27	W. M. Perrine.	5.00
"	27	M. W. Hassett..	5.00
"	27	M. G. Brown...	5.00
"	27	L. L. Dawson...	5.00
"	27	H. Sneck	5.00
"	28	D. J. Mullin....	5.00
"	30	J. Hainen	5.00
"	30	T. D. Mannion.	5.00
July	5	C. H. Quereau..	5.00
"	5	W. F. M. Goss.	5.00
"	5	W. F. Walsh...	5.00
"	5	Sam'l Higgins..	5.00
"	5	R. T. Shea.....	5.00
"	5	G. W. Rink.....	5.00
"	5	K. L. Dresser..	5.00
"	5	W. H. Wilson..	5.00
"	5	J. G. Neuffer...	5.00
"	5	E. C. Schmidt..	5.00
"	5	J. S. Bell.....	5.00
"	5	E. English	5.00
"	5	G. N. Howson..	5.00
"	5	I. N. Kalbaugh.	5.00
"	5	C. H. Wiggins.	5.00
"	5	S. N. Woodruff.	10.00
"	5	J. H. Manning.	5.00
"	5	S. M. Vauclain.	5.00
"	5	W. W. Atterbury	5.00
"	5	Thos. Paxton...	5.00
"	5	F. A. Delano...	5.00
"	5	W. B. Russell..	5.00
"	5	W. H. V. Rosing.	5.00
"	5	G. M. Gray.....	5.00
"	5	A. A. Maver....	5.00
"	5	E. A. Walton...	5.00
"	5	J. H. Waters...	5.00
"	5	R. J. Gross....	5.00
"	5	P. Wallis	5.00
"	5	J. S. Turner...	5.00
"	5	G. S. Hodging..	5.00
"	5	W. E. Chester..	5.00
"	5	J. A. Carney...	5.00
"	5	L. C. Noble....	5.00
	Carried forward	$	911.00

Digitized by Google

		Brought forward	$ 911.00
July	5	Jos. Roberts....	5.00
"	5	C. H. Jones....	5.00
"	5	W. L. Reid.....	5.00
"	5	J. J. Ewing....	10.00
"	5	R. D. Smith....	5.00
"	5	H. M. Carry....	5.00
"	5	C. E. Keenan...	5.00
"	5	L. B. Morehead.	5.00
"	5	G. Lanza	5.00
"	5	C. H. Davis....	5.00
"	5	W. Kells	5.00
"	5	J. E. Muhlfeld..	5.00
"	5	W. B. Leach...	5.00
"	5	B. Haskell	5.00
"	5	D. F. Walsh....	5.00
"	5	Thos. Marshall.	5.00
"	5	H. A. Gillis....	5.00
"	5	R. L. Wyman..	5.00
"	5	F. P. Roesch...	5.00
"	5	C. T. Noyes....	5.00
"	5	G. A. Moriarty.	5.00
"	5	S. L. Kneass...	5.00
"	5	J. W. Oplinger.	5.00
"	5	J. R. Magarvey.	5.00
"	5	H. T. Thomas..	5.00
"	5	F. Mertsheimer.	5.00
"	5	G. N. Riley.....	5.00
"	6	B. H. Hawkins.	5.00
"	6	F. Hedley	5.00
"	6	J. L. Larellee..	5.00
"	6	W. E. Symons.	5.00
"	6	Jno. Mackenzie.	5.00
"	6	C. B. Royal....	5.00
"	6	C. Coleman	5.00
"	6	R. Patterson ...	5.00
"	6	L. L. Bentley..	5.00
"	6	Tracy Lyon	5.00
"	6	W. T. Smith...	5.00
"	8	G. J. DeVilbiss.	5.00
"	8	M. J. Drury....	5.00
"	8	G. Wirt	5.00
"	8	A. J. Poole....	5.00
"	8	W. N. Best....	5.00
		Carried forward	$1,131.00

		Brought forward	$1,131.00
July	8	J. E. Mathis....	5.00
"	8	J. A. Graham..	5.00
"	8	W. H. Stocks..	5.00
"	8	F. W. Brazier..	5.00
"	8	F. S. Hoffmaster.	5.00
"	8	J. W. Fogg....	5.00
"	8	W. H. Rieckman	10.00
"	8	W. H. Traver..	5.00
"	8	H. W. Jacobs..	5.00
"	8	A. M. White...	5.00
"	8	C. J. Stewart..	5.00
"	8	C. A. Seley....	5.00
"	8	J. J. Monahan..	5.00
"	8	S. F. Prince...	5.00
"	8	J. E. Sague....	5.00
"	8	B. P. Flory....	5.00
"	8	W. H. Collins..	5.00
"	8	H. M. Fflager...	5.00
"	8	W. S. Handcock	5.00
"	8	Robt. Quayle...	5.00
"	8	J. P. McCuen..	5.00
"	8	W. O. Thompson	5.00
"	8	J. C. Glass.....	5.00
"	8	R. T. Jaynes....	5.00
"	8	W. B. Lipscombe	5.00
"	8	F. A. Torrey...	5.00
"	8	T. L. Burton...	5.00
"	8	J. E. Keegan...	5.00
"	8	G. M. Basford..	5.00
"	8	C. F. Chase....	10.00
"	8	J. W. Cross....	5.00
"	8	W. Schlafge....	5.00
"	8	Wm. Renshaw..	5.00
"	8	J. Hainen	5.00
"	8	T. D. Mannion.	5.00
"	12	J. B. Michael...	5.00
"	12	F. J. Walsh....	5.00
"	12	G. L. Wall.....	5.00
"	12	S. P. Bush.....	5.00
"	12	T. W. Heintzleman	5.00
"	12	A. Forsyth	5.00
"	12	T. W. McCarthy	5.00
		Carried forward	$1,351.00

Digitized by Google

		Brought forward	$1,351.00
July	12	S. S. Riegel....	5.00
"	12	A. Turner	5.00
"	12	W. L. Austin...	5.00
"	12	Wm. Dalton ...	5.00
"	12	W. H. Marshall	5.00
"	12	W. J. Bennett..	10.00
"	12	L. G. Parish...	5.00
"	12	J. E. Irwin.....	5.00
"	12	P. Maher	5.00
"	12	J. T. Hayes....	5.00
"	12	J. K. Brassill..	5.00
"	12	G. A. Hancock..	5.00
"	12	E. B. Gilbert...	5.00
"	12	D. W. Fitzgerald	5.00
"	12	J. Dickson	5.00
"	12	A. C. Adams...	5.00
"	12	J. N. Johnston..	5.00
"	12	Wm McIntosh..	5.00
"	12	H. Emerson....	5.00
"	12	F. H. Scheffer..	5.00
"	12	J. E. Gould....	5.00
"	12	J. W. Addis....	5.00
"	12	W. H. Robinson	10.00
"	12	A. McCormick..	5.00
"	12	J. Horrigan	5.00
"	12	H. B. Hunt.....	5.00
"	12	C. B. Young...	5.00
"	12	F. H. Clark....	5.00
"	12	W. F. Kapp....	5.00
"	13	C. F. Street....	5.00
"	13	J. A. Beamer...	5.00
"	13	G. E. Branch...	5.00
"	13	J. A. Egan.....	5.00
"	13	A. G. Leonard..	5.00
"	15	H. Monkhouse..	5.00
"	15	G. W. Lillie....	5.00
"	15	G. Gilmour	5.00
"	15	Max Toltz	15.00
"	15	A. B. Johnson..	5.00
"	15	L. B. Ferguson.	5.00
"	15	T. W. Demarest	5.00
"	15	T. E. Keyworth.	5.00
		Carried forward	$1,581.00

		Brought forward	$1,581.00
July	15	Geo. Gibbs	5.00
"	15	E. F. Needham.	5.00
"	15	C. M. Harris...	10.00
"	15	W. C. Hayes...	5.00
"	15	W. White	10.00
"	15	E. O. Rollings..	5.00
"	18	G. C. Bishop...	5.00
"	18	T. E. Adams...	5.00
"	18	J. A. Hill.....	5.00
"	18	J. J. Hanlan....	5.00
"	18	D. M. Pearsall..	5.00
"	18	J. W. Harkom..	5.00
"	18	H. T. Herr....	5.00
"	18	G. H. Emerson.	5.00
"	18	H. H. Maxfield.	5.00
"	18	D. J. Redding..	5.00
"	18	R. E. Smith....	5.00
"	18	J. W. Cloud....	5.00
"	18	E. B. Thompson	5.00
"	18	H. T. Peyton..	5.00
"	18	A. B. Phillips..	5.00
"	18	H. J. Small....	5.00
"	18	L. H. Turner..	5.00
"	18	S. T. Park.....	5.00
"	18	C. D. Young...	5.00
"	18	D. F. Crawford	5.00
"	18	W. A. Nettleton	5.00
"	18	W. J. Tollerton.	5.00
"	18	G. A. Bruce....	10.00
"	18	H. B. Ayers....	5.00
"	18	H. S. Hayward.	5.00
"	18	R. N. Durborow	5.00
"	18	M. H. Haig....	5.00
"	18	L. S. Kinnard..	5.00
"	18	G. R. Joughins.	5.00
"	18	J. N. Mowery..	5.00
"	18	A. Allan	5.00
"	18	H. T. Bruck....	5.00
"	18	Jno. Hill	5.00
"	18	T. H. Curtis...	5.00
"	21	G. R. Bennett..	5.00
"	21	J. D. Harris....	5.00
"	21	J. H. Davis....	5.00
		Carried forward	$1,811.00

Digitized by Google

Brought forward			$1,811.00
July	21	J. T. Carroll...	5.00
"	21	A. P. Prendergast	5.00
"	21	B. B. Cargo....	5.00
"	21	T. Hamilton ...	5.00
"	21	P. M. Hammett.	5.00
"	21	Wm. Bawden...	5.00
"	21	J. E. Goodman.	5.00
"	21	T. F. Dreyfus..	5.00
"	21	W. A. Smith...	5.00
"	23	E. Dawson	5.00
"	23	C. H. Seabrook.	5.00
"	23	A. Stewart	5.00
"	23	Jno. Wahlen...	5.00
"	23	E. E. Davis....	5.00
"	23	F. O. Walsh...	5.00
"	23	R. A. Billingham	5.00
"	23	E. D. Bronner..	5.00
"	23	F. F. Small....	5.00
"	23	E. W. Burgis..	5.00
"	23	J. S. Chambers.	5.00
"	23	F. H. Clark....	5.00
"	25	E. M. Sweetman	5.00
"	25	Jno. Milliken ..	5.00
"	25	W. J. Spearman	5.00
"	25	D. E. Cassidy..	5.00
"	25	C. D. Vanaman.	5.00
"	25	J. F. Enright...	5.00
"	25	G. T. Churchward	5.00
"	25	D. J. Justice....	5.00
"	25	F. A. Casey....	5.00
"	25	J. G. Blunt.....	5.00
"	27	Thos. Fraser...	5.00
"	27	T. A. Brown...	5.00
"	27	E. A. Miller...	5.00
	27	E. L. Weisgerber	5.00
"	27	W. C. A. Henry.	5.00
"	27	D. W. Ford....	5.00
"	27	F. T. Slayton..	5.00
"	27	C. E. Fuller....	5.00
"	27	C. W. Seddon..	5.00
Carried forward			$2,011.00

Brought forward			$2,011.00
July	27	J. M. Burley...	5.00
"	29	F. S. Anthony..	5.00
"	29	F. E. Davisson.	5.00
"	29	W. F. Dixon...	10.00
"	29	B. H. Grey.....	5.00
"	29	A. Shields	5.00
"	29	H. A. Monfee..	5.00
"	29	J. R. Groves....	5.00
"	29	F. F. Gaines...	5.00
"	29	J. J. Ryan.....	5.00
"	29	Jno. Hair	5.00
"	29	F. J. Smith....	5.00
"	29	P. H. Reeves...	5.00
"	29	M. K. Barnum.	5.00
"	29	W. T. Thompson	5.00
"	29	S. M. Dolan...	15.00
"	29	F. C. Cleaver..	5.00
"	29	Max Goodrich..	5.00
"	29	H. Weitzel	5.00
"	29	J. T. Luscombe.	5.00
"	29	E. G. Courtney.	5.00
"	29	R. W. Bell.....	5.00
"	29	G. S. McKee...	5.00
"	29	H. P. Durham..	5.00
Aug.	5	Frank Johnson.	5.00
"	5	H. S. Bryan....	5.00
"	5	C. H. Prescott.	5.00
"	5	L. R. Pomeroy.	5.00
"	5	Geo. Thompson.	5.00
"	5	D. R. MacBain.	5.00
"	5	S. K. Dickerson	5.00
"	5	A. R. Ayers....	5.00
"	5	Jos. Chidley....	5.00
"	5	O. M. Foster...	5.00
"	5	M. D. Franey..	5.00
"	5	J. T. McGrath.	5.00
"	5	F. P. Hickey...	10.00
"	5	W. D. Robb....	5.00
"	5	J. M. Robb.....	5.00
"	5	J. R. Gould....	5.00
"	5	J. P. Nolan....	5.00
"	5	F. H. Regan....	5.00
Carried forward			$2,241.00

Digitized by Google

Brought forward			$2,241.00
Aug.	5	W. G. Wallace.	5.00
"	5	Henry Fowler..	5.00
"	5	I. W. Fowle....	5.00
"	5	Jno. Nicholson..	5.00
"	5	A. R. Ayers....	5.00
"	5	A. E. Manchester	5.00
"	5	W. H. Richmond	5.00
"	5	L. A. Petries...	10.00
"	23	C. H. Howard..	5.00
"	23	J. T. Flavin....	5.00
"	23	J. F. Dunn.....	5.00
"	23	A. R. Kipp.....	5.00
"	23	T. A. Foque...	5.00
"	23	Thos. Roope ...	5.00
"	23	W. J. Shreeve..	5.00
"	23	W. J. McGee...	5.00
"	23	L. H. Fry.....	5.00
"	23	H. D. Gordon..	5.00
"	23	J. H. Nash.....	5.00
"	23	G. E. Knight...	5.00
"	23	C. A. Woodcock	5.00
"	23	A. C. Russell...	5.00
"	23	G. H. Bussing..	5.00
"	23	Alfred Williams	15.00
"	23	H. L. Leach....	5.00
"	19	H. Tandy	5.00
"	23	Jno. Cullinan...	5.00
"	23	A. W. Gibbs...	5.00
"	23	H. P. Meredith.	5.00
"	23	E. D. Nelson...	5.00
"	23	C. M. Tritsch..	5.00
"	23	Robt. Tawse....	5.00
"	23	A. S. Vogt.....	5.00
"	23	W. H. Lewis...	5.00
"	23	A. Kearney	5.00
"	23	H. F. Greenwood	5.00
"	23	T. R. Cook.....	5.00
"	23	Wm. Garstang..	5.00
"	23	Thos. Yeager...	5.00
"	23	J. S. Cook.....	5.00
"	23	H. C. Van Buskirk	5.00
Carried forward			$2,461.00

Brought forward			$2,461.00
Aug.	23	Henry Bartlett..	5.00
"	23	C. M. Taylor...	5.00
"	23	Jas. McNaughton	5.00
"	23	C. B. Keiser....	5.00
"	23	J. T. White....	10.00
"	23	Jas. Kirkpatrick	5.00
"	23	P. J. Harrigan.	5.00
"	23	T. R. Stewart..	5.00
"	23	W. Sinnot	5.00
"	23	J. F. Prendergast	5.00
"	23	G. H. Likert...	5.00
"	23	W. F. Kaderly.	5.00
"	23	W. Dunham ...	5.00
"	23	J. A. McRae...	5.00
"	23	J. H. McConnell	5.00
"	23	W. J. Wilcox...	5.00
"	23	W. T. Fitzgerald	5.00
Sept.	30	E. C. Bates....	5.00
"	30	J. E. O'Herin..	5.00
"	30	Angus Sinclair.	5.00
"	30	F. F. Hildreth..	5.00
"	30	A. L. Studer...	5.00
"	30	G. F. Wilson...	5.00
"	30	J. R. Van Cleve	5.00
"	30	G. L. Fowler...	5.00
"	30	D. E. Davis....	5.00
"	30	W. H. Brehm...	5.00
"	30	Geo. Wagstaff..	5.00
"	22	H. Montgomery	5.00
"	30	C. W. Stevenson	5.00
"	30	C. D. Hilferty..	5.00
"	30	J. B. Purdy.....	5.00
"	30	G. R. Henderson	5.00
"	30	H. N. Breneman	5.00
"	30	C. W. Cross....	5.00
"	30	Richard English	5.00
"	30	Jesse Gauthier..	5.00
"	30	A. M. Waitt....	5.00
"	30	R. D. Hawkins.	10.00
"	30	H. G. Bechhold.	5.00
"	30	D. O'Leary	5.00
Carried forward			$2,676.00

Digitized by Google

Brought forward			$2,676.00
Sept.	30	A. W. Bannatyne	5.00
"	30	J. E. Mechling..	5.00
"	30	Roland Finch...	10.00
"	30	W. F. Kiessel..	5.00
"	30	C. B. Hathaway.	5.00
"	30	M. Yoshino ...	5.00
"	30	L. B. Rhodes...	5.00
"	30	R. P. Blake....	5.00
"	30	E. H. Sweeney.	5.00
"	30	A. J. Cota.....	5.00
"	30	J. W. Gibbs....	5.00
"	30	F. E. Marsh...	5.00
"	30	C. B. Smith....	5.00
"	30	W. H. Hamilton	5.00
"	30	T. J. MacPherson	5.00
"	30	R. A. Smart....	5.00
"	30	J. C. Mengel...	5.00
"	30	Jas. Marchbanks	5.00
"	30	J. O. Warthen..	5.00
"	30	L. S. Randolph.	15.00
"	30	V. C. Caracristi.	5.00
"	30	F. H. Litton....	5.00
"	30	P. H. Murphy..	5.00
"	30	Geo. Ridgway..	5.00
"	30	Robt. Moran....	5.00
"	30	R. B. Kendig...	5.00
"	30	S. G. Thompson	5.00
"	30	W. T. Foster...	5.00
"	30	C. F. Roberts...	5.00
"	30	A. B. Appler...	5.00
Oct.	24	A. G. Kurman..	5.00
"	24	R. E. McCuen..	5.00
"	24	W. H. Bennett.	5.00
"	24	Jos. Davis	5.00
"	24	I. B. Thomas...	5.00
"	24	H. M. C. Skinner	5.00
"	24	R. H. Rogers...	10.00
"	24	A. F. Stewart..	5.00
"	24	A. A. Campbell.	10.00
"	24	C. H. Potts....	5.00
"	24	J. M. Henry....	5.00
"	24	Elliott Sumner..	5.00
Carried forward			$2,911.00

Brought forward			$2,911.00
Oct.	24	C. K. Shelby...	5.00
"	24	M. R. Coutant..	5.00
"	24	M. H. Wickhorst	5.00
"	24	J. G. Beaumont.	5.00
"	24	L. L. Collier...	5.00
"	24	H. B. Howe....	5.00
"	24	C. M. Hoffman.	10.00
"	25	E. S. Hume....	5.00
"	25	Jno. Shelaberger	5.00
"	25	M. Marea	5.00
"	25	T. G. Ferguson.	5.00
"	25	C. J. Thornton.	5.00
"	25	J. G. Platt.....	5.00
"	25	E. F. Jones....	5.00
Nov.	4	Frank Slater....	5.00
"	4	G. F. Hess.....	5.00
"	4	D. A. Wightman	5.00
"	4	M. E. Cleland..	5.00
"	4	F. A. Smock...	5.00
"	4	J. L. Greatsinger.	5.00
"	4	Jno. Sibbald....	5.00
Dec.	21	C. G. Turner...	5.00
"	21	F. M. McNulty.	5.00
"	21	R. Atkinson ...	15.00
"	21	Wm. O'Herin...	5.00
"	21	Henry Pollitt...	5.00
"	21	W. C. Squire...	10.00
"	21	W. M. Paul....	5.00
"	21	W. D. Holland.	5.00
"	21	R. J. Goodale..	5.00
"	21	R. E. French...	10.00
"	21	W. S. Morris..	5.00
"	21	Henry Tregelles.	10.00
"	21	J. M. James....	5.00
"	21	A. G. Machesney	5.00
"	21	Geo. Dickson...	5.00
"	21	C. L. Meister..	5.00
"	21	W. Cross	5.00
"	21	W. R. McKeen.	5.00
"	22	W. J. McLean..	5.00
"	22	E. W. Pratt....	10.00
"	22	F. P. Pfahler..	5.00
"	22	J. B. Cameron..	5.00
Carried forward			$3,161.00

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Brought forward		$3,161.00
Dec. 22	Wm. Gill	5.00
" 22	Wm. Forsyth...	5.00
" 22	A. Lovell	5.00
1911.		
Jan. 20	Jas. Fitzmorris..	5.00
" 20	S. Suzuki	5.00
" 20	W. E. Amann..	5.00
" 20	W. J. McGee...	5.00
" 20	J. D. Maupin...	5.00
" 20	T. Rumney	5.00
" 20	H. J. Osborne..	5.00
" 20	J. C. Nascimento	5.00
" 20	Jno. Howard...	5.00
" 20	H. E. Smith....	5.00
Mar. 14	H. A. Lydon...	5.00
" 14	N. W. Sample..	10.00
" 14	B. D. Lockwood	5.00
" 14	G. Willius	5.00
" 14	C. M. Stansbury	5.00
" 14	G. D. Brooke..	5.00
" 14	H. W. Hibbard.	5.00
" 14	J. J. Sullivan...	5.00
" 14	J. A. Pilcher....	5.00
" 14	H. J. Tierney..	5.00
" 14	Wm. Augustus.	5.00
" 14	C. W. Hayes...	5.00
" 14	W. H. Flynn...	10.00
" 14	W. E. Knight..	5.00
" 14	Robt. Preston...	10.00
" 14	J. J. Bayley....	5.00
" 14	G. A. Miller...	5.00
" 14	T. C. Link.....	5.00
" 14	W. L. Allison..	5.00
" 14	A. C. Deverell.	5.00
" 14	J. B. Edwards..	5.00
" 14	R. F. Hoffman.	5.00
" 14	G. P. Goodrich.	5.00
" 14	A. Dinan	5.00
" 14	C. R. Ord.....	5.00
" 14	W. S. Gallaway.	5.00
" 14	C. A. Delaney..	5.00
" 14	A. B. Todd.....	5.00
" 14	H. C. Oviatt...	5.00
Carried forward		$3,386.00

Brought forward		$3,386.00
Mar. 14	H. B. McFarland	5.00
" 14	B. P. Myers....	10.00
" 14	Jos. McCabe ...	5.00
" 14	I. M. Malone...	5.00
" 14	Jas. Ashworth..	10.00
" 14	F. J. Zerbee....	10.00
" 14	W. J. Haynen..	10.00
" 14	C. K. Bowles...	10.00
" 14	A. L. Humphrey	5.00
" 14	Owen Clark ...	5.00
" 14	W. L. Tracy...	5.00
" 14	Alfred White...	15.00
" 14	R. B. Watson...	5.00
" 15	J. W. Storey...	5.00
" 15	C. A. Thompson	5.00
" 15	C. E. Allen....	5.00
" 15	G. H. Baker....	5.00
" 15	H. H. Vaughan.	5.00
" 15	C. E. Slayton...	10.00
" 15	Thos. Walsh ...	5.00
" 15	R. H. Briggs...	5.00
" 15	Pat Ryan	5.00
" 15	H. F. Ball.....	5.00
" 15	S. N. Woodruff.	5.00
" 15	W. F. Yergens..	15.00
" 15	Sam Shepard...	5.00
" 15	D. A. Smith....	5.00
" 15	E. S. Eden.....	5.00
" 15	Chas. DeGress..	5.00
" 15	T. S. Lloyd.....	5.00
" 15	E. A. Williams.	5.00
" 15	T. McNabb	5.00
" 15	T. Larry	10.00
" 15	E. C. Haggett..	5.00
" 15	A. W. Lord....	5.00
" 15	J. B. Miller.....	5.00
" 15	Wm. Elmer	5.00
" 15	L. L. Smith.....	10.00
" 15	G. C. Bornfeld.	5.00
" 15	M. A. Malloy..	5.00
" 15	E. S. Fitzsimmons	10.00
" 15	G. H. Haselton.	5.00
Carried forward		$3,671.00

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Brought forward			$3,671.00
Mar.	15	W. H. Russell..	5.00
"	15	J. M. Lynch....	10.00
"	15	M. E. Wells....	5.00
Apr.	13	F. M. Whyte...	5.00
"	13	W. B. Gaskins..	10.00
"	13	P. C. Rusch....	5.00
"	13	D. M. Pearsall..	5.00
"	13	C. R. Williams.	5.00
"	13	F. G. Grimshaw	5.00
"	13	G. W. Seidel...	5.00
"	13	Robt. Gould ...	5.00
"	13	S. J. Dillon....	5.00
"	13	F. F. Walsh....	5.00
"	13	Jas. McDonough	5.00
"	14	L. Greaven	10.00
"	14	C. F. Gregory..	5.00
"	14	R. Griffith	10.00
"	14	W. H. Watkins.	10.00
"	14	J. H. Maysilles.	5.00
"	14	J. S. Booth....	5.00
"	14	L. R. Johnson..	5.00
"	14	R. V. Wright..	5.00
"	14	P. J. Meade....	5.00
"	14	M. G. Bock.....	5.00
"	14	Thos. Jennings.	5.00
"	14	F. W. Rhuark..	5.00
"	14	J. P. McCuen..	5.00
"	14	A. H. Watts....	5.00
"	14	W. S. Grandy..	10.00
"	14	F. Monlaverdo..	15.00
"	14	P. D. Plank....	5.00
May	5	G. L. Dickson..	5.00
"	5	L. C. Todd.....	5.00
"	5	Wm. Moir	5.00
"	5	J. L. Smith.....	5.00
"	5	J. G. Clifford...	5.00
"	5	C. T. McElvaney	5.00
"	5	H. G. Hudson..	5.00
"	5	E. J. Snell.....	5.00
"	5	J. J. Dewey....	10.00
"	5	J. C. Little.....	5.00
"	5	R. E. Osborne..	10.00
"	5	J. C. Fraps.....	5.00
Carried forward			$3,936.00

Brought forward			$3,936.00
May	5	S. Phipps	5.00
"	5	J. Neville	5.00
"	5	Wm. Cockfield..	5.00
"	5	H. H. Harrington	5.00
"	5	W. P. Carroll...	5.00
"	5	Thos. Aldcorn..	5.00
"	5	H. C. Manchester	5.00
"	5	J. A. Gibson....	5.00
"	5	F. W. Mahl....	5.00
June	5	Jas. Cole	5.00
"	5	G. M. Crownover	5.00
"	5	C. H. Spengler.	5.00
"	5	R. P. C. Sanderson	10.00
"	5	W. S. Clarkson.	10.00
"	5	W. C. Burel....	5.00
"	5	H. Jackson	10.00
"	5	G. A. Miller....	5.00
"	5	R. H. Johnson..	10.00
"	5	J. A. Riberio...	5.00
"	5	H. E. Walker..	10.00
"	5	L. K. Smith.....	5.00
"	5	W. L. Larry....	10.00
"	5	W. H. Foster..	5.00
"	5	H. M. Miller...	10.00
"	5	N. Frey	15.00
"	5	J. M. Dow.....	5.00
"	5	P. J. Hickey...	10.00
"	5	R. Atkinson.....	5.00
"	5	C. J. Bushmeyer	5.00
"	5	I. C. Hicks.....	10.00
"	5	D. J. Durrell...	10.00
"	5	A. J. Fries.....	5.00
"	5	Bert Hartigan..	5.00
"	5	T. J. Cutler....	5.00
"	5	D. G. Desmond.	5.00
"	5	J. Christopher..	5.00
"	5	P. M. McDougall	5.00
"	5	C. M. Muchnic.	5.00
"	5	J. I. Krauss....	5.00
"	5	R. G. Cox.....	5.00
"	5	G. S. Edmonds.	5.00
Carried forward			$4,201.00

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Brought forward			$4,201.00
June	5	J. P. Dolan.....	5.00
"	5	J. H. McGoff...	5.00
"	5	A. H. Cairns...	10.00
"	5	E. L. Martin...	10.00
"	5	C. D. Kinney...	5.00
"	5	W. H. Murray.	5.00
"	5	Rufus Hill	5.00
"	5	Geo. Akans	5.00
"	5	E. H. Gorey....	5.00
Carried forward			$4,256.00

Brought forward			$4,256.00
June	5	R. L. Ettenger..	5.00
"	5	J. F. Sheahan..	5.00
"	5	E. C. Sasser....	5.00
"	5	Wm. Lachlan...	5.00
"	5	H. F. Wardwell	5.00
"	5	H. S. Wall.....	5.00
"	5	W. T. Foster...	5.00
"	5	J. E. Chisholm.	5.00
"	5	J. J. Conners...	10.00
Total			$4,306.00

TREASURER'S REPORT.

American Railway Master Mechanics' Association.

1910.		
June 20, balance, as per last report.....	$6,229.94	
June 29, interest, April, May and June.....	30.75	
September 29, interest, July, August and September	31.22	
December 1, coupon, bond, Jerome & Wheelock	20.00	
December 29, interest, October, November and December	30.90	
1911.		
March 29, interest, January, February and March	30.62	
June 1, coupon, bond, Jerome and Wheelock	20.00	
		$6,393.43
Received from Secretary.....		96.13
June 12, balance on hand.....		$6,489.56

ANGUS SINCLAIR,
Treasurer.

THE PRESIDENT: You have heard the report of the Secretary and Treasurer. What is your pleasure?

MR. C. A. SELEY (C. R. I. & P. Ry.): I move that the report of the Secretary and Treasurer be referred to the Auditing Committee. Motion seconded and carried.

THE SECRETARY: The Executive Committee at its meeting

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last evening recommended that the dues for the ensuing year be fixed at $5 per vote, the same as last year.

THE PRESIDENT: Gentlemen, are you ready for the question on approving the action of the Executive Committee in fixing the dues at $5 for the ensuing year?

MR. T. H. CURTIS (L. & N. R. R.): I move that the action of the Executive in that regard be approved.

MR. J. D. HARRIS (B. & O.): I second the motion.

THE PRESIDENT: All in favor of the motion say "aye"; opposed "no." Carried.

THE SECRETARY: I extended an invitation to the Traveling Engineers' Association to have a representative present at this convention if they desired to appoint one, but I have not been advised whether a representative has been named or not.

THE PRESIDENT: Is there any officer representing the Traveling Engineers' Association present? Perhaps Mr. Hayes can inform us.

MR. W. C. HAYES: I am not advised as to who is authorized to represent the Traveling Engineers' Association at this convention. So I could not give the desired information.

THE PRESIDENT: Then we will pass that. The next order of business is the election of an Auditing Committee. Nominations from the floor will be in order for three members.

MR. J. F. DEVOY (C. M. & S. P. Ry.): I nominate Mr. C. H. Rae.

MR. T. H. CURTIS (L. & N. R. R.): I nominate Mr. J. W. Fogg.

MR. G. W. WILDIN (N. Y. N. H. & H. R. R.): I nominate Mr. M. J. McCarthy.

MR. E. W. PRATT: I move that the nominations be closed.

The motion was seconded.

THE PRESIDENT: All in favor of the motion that the nominations be declared closed will say "aye"; opposed "no." Carried.

All those in favor of the election of Messrs. Rea, Fogg and McCarthy as members of the Auditing Committee will say "aye"; opposed "no." Carried.

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THE SECRETARY: I will say to the gentlemen that the books of the Secretary and Treasurer are ready for their inspection at any time.

I have received the following notice from the Pennsylvania Lines:

> Kindly notify the railroad members of the Master Car Builders' and Master Mechanics' Associations wishing transportation home over the lines of the Pennsylvania Railroad Company, or the Pennsylvania Lines west of Pittsburgh, that such transportation will be provided if they hand you their names. Owing to the requirements of the law this transportation must be limited to bona fide railroad officials only, and can not include members of belt lines, car lines, or switching roads operated by industries.

Any members wishing to avail themselves of this transportation will present their credentials to me and I will see that they have their transportation arranged by Friday morning.

THE PRESIDENT: Is there any other unfinished business?

THE SECRETARY: At the last convention the name of Prof. Louis E. Endsley, Association Professor of Railway Mechanical Engineering at Purdue University, was proposed for Associate Membership in this Association.

THE PRESIDENT: This application, gentlemen, has laid over for a year in accordance with the Constitution and By-Laws, and it is in order now for this convention to take action as to whether or not it desires to have Professor Endsley as an Associate Member.

MR. WILDIN: I move that the application be granted.

MR. PRATT: I second the motion.

THE PRESIDENT: It has been moved and seconded that Professor Endsley be made an Associate Member of the Association. All in favor of the motion will say "aye"; opposed "no." Carried.

THE SECRETARY: The name of E. A. Averill, Managing Editor of the *American Engineer and Railroad Journal,* was proposed last year for membership, and it has laid over the required time.

MR. SELEY: I move that Mr. Averill's name be added to the roll of membership.

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MR. GAINES: I second the motion.

THE PRESIDENT: It is moved and seconded that the name of Mr. E. A. Averill, Managing Editor of the *American Engineer and Railroad Journal,* be added to the list of Associate Members of the Association. All in favor of the motion will say "aye"; opposed "no." Carried.

THE SECRETARY: The following committees have been named to prepare obituaries:

T. Rummey, for D. F. Van Ripper; J. W. Taylor, for H. H. Johnson; G. W. Wildin, for J. B. Gannon; Angus Sinclair, for David Brown; J. J. Conolly, for H. S. Bryan; M. A. Kinney, for G. T. DeVelbiss; C. E. Chambers, for P. G. Thomas; J. W. Taylor, for J. Piccoli.

THE SECRETARY: I have another notice here from Mr. H. D. Taylor, Superintendent of Motive Power of the Reading Railway, reading as follows:

In the Reading passenger station the Philadelphia & Reading Railroad has a three-cylinder engine with tender equipped with the Hewitt Universal truck; also two hopper cars with Hewitt-Bettendorf and Hewitt-Gould trucks, and will be glad to have the members look them over.

At a meeting of the Executive Committee last evening the matter of the scholarships held by this Association was considered and it was suggested that the Secretary give to the members this morning somewhat briefly a statement as to what the scholarships are.

The Association has four scholarships at the Stevens Institute of Technology. The expense for tuition at the institute is taken care of by the fund we have there, but it does not include board or rooms. There are no vacancies at the present time and there will be none until September, 1912. The requirements, as contained in the Constitution, are as follows:

Acceptable candidates for the scholarship shall be, first, sons of deceased members of the Association. If there is not a sufficient number of such applicants for the June examination, then applications will be received from other railroad employees or the sons of other railroad employees for the fall examination. The Secretary shall issue a proper circular in this case as before. In extending the privilege outside of the

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families of members, preference shall be given to employees or the sons of employees, or the sons of deceased employees of the mechanical departments.

Candidates for these scholarships shall apply to the Secretary of this Association, and if found eligible shall be given a certificate to that effect for presentation to the school authorities. This will entitle the candidate to attend the preliminary examination. If more than one candidate passes the preliminary examination, the applicant passing the highest examination shall be entitled to the scholarship, the school authorities settling the question.

The successful candidate shall be required to take the course of mechanical engineering.

We also have a scholarship at Purdue University, given by Joseph T. Ryerson & Son, of Chicago, the conditions of which are somewhat different. They appropriate five or six hundred a year, which takes care of the school expense as well as board and rooms for the student. Mr. Houston finishes his term this spring, and the Ryerson people say "if your Association desires to coöperate with us we are willing to extend this another four years." The Executive Committee accepted this offer, and I will take up with the school authorities the matter of issuing notices to the members in regard to this scholarship as soon as I return to Chicago.

THE PRESIDENT: In the matter of scholarships there has not been the number of applications that would naturally be expected in an organization having a membership of a thousand or over. With the number of members engaged in railroad work, there should be no difficulty in securing applicants for these scholarships. If you have not followed Mr. Roosevelt's advice and had a large family of your own, so that the candidates for these scholarships may be selected from among your sons, you certainly must have under your management some bright young men who can be brought into the scholarships.

We have felt that it was not generally known we had these scholarships, and for that reason the matter has been brought up in more detail than would seem necessary, in order to refresh the memories of the members of the Association. We should not let these scholarships go by default. If there are any members of your own families eligible for these scholarships, the opportunity should certainly be taken advantage of, and if not, some worthy

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young fellow in the railroad service should be given a chance to receive the benefits of a technical education.

If there is no other new business to bring before the convention, we will proceed with our work of discussing the reports. The first report is that of the Committee on Advisory Technical, Mr. G. W. Wildin (N. Y. N. H. & H. R. R.), Chairman.

MR. G. W. WILDIN: As chairman of this committee, I desire at this time to merely report progress. A number of things have come up during the past year which have prevented the committee from making any definite recommendations at this time, among which is the possibility of a consolidation of the two Associations, and other matters of like nature. I think the experience of the past year or so, with legislative matters, clearly indicates that such a committee is desirable. After listening to the President's address, I wish to call the attention of the Executive Committee to the fact that if the Committee on Advisory Technical follows the line of work as it is supposed to do, and the committee that the President has recommended is appointed, they will both be practically doing the same work and one or the other should be eliminated. Of course, that will be a matter for the Executive Committee to decide.

THE PRESIDENT: Are there any more remarks to be made on this subject? We would be glad to hear the views of the members. It is a very important subject, but if there is nothing more to be said, we will proceed with the work of the convention.

The next business is the report of the Committee on Mechanical Stokers, Mr. T. Rumney, chairman of the committee.

Mr. Rumney presented the report, as follows:

REPORT OF COMMITTEE ON MECHANICAL STOKERS.

To the Members:

Your committee feels fully justified in expressing the opinion that such progress has been made in the development of mechanical stokers to warrant railroads installing a limited number upon large locomotives at least, and thus lend their aid in the perfection of a device which your committee has concluded is a necessary appliance to heavy tractive-power

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locomotives, when such locomotives are called upon to exert their full capacity for a prolonged period.

The large locomotives at present being constructed would unquestionably render service nearer their maximum capacity if the firing were mechanical, and your committee is of the opinion that it behooves the members of this Association to participate actively by utilizing such stokers as have been developed, and, by actual application, assist in the solving of the many problems which must naturally present themselves during practical operation.

The benefits to be derived might properly be again referred to, viz.:

Utilization of the maximum boiler capacity of locomotives;

Reduction of black smoke, because of the possibility of maintaining a thin, level fire;

Application of coal in more minute quantities;

Improved life of flues and fire boxes;

The reduced labor required should make the positions of firemen more attractive, which will carry therewith obvious benefits to the railroads.

The requirements for mechanical stokers, as recommended by your committee, in brief, are:

That they should be capable of firing coal in excess of the maximum requirements of the locomotive;

That the fire-box door be free of any attachment which would prevent the fireman from giving such attention as fires may require;

Be entirely mechanical from tender to grate;

Be capable of handling bituminous run-of-mine coal, which will include a coal crusher, mechanically operated, on the tender;

Distribute the coal in the fire box in such a manner as to call for no assistance from the fireman other than regulation of supply and possibly the adjustment of the mechanical appliances for distribution;

Maintain an ideal fire for economic coal consumption without emission of black smoke in objectionable quantities;

Reliability of service.

Previous reports of your committee have directed attention to various mechanical stokers under development, and a summary upon each is presented, with such remarks as are believed pertinent to the subject.

CRAWFORD UNDERFEED STOKER.

This stoker is in service on the Pennsylvania Railroad; its operation has been satisfactory; it is completely mechanical and aims to cover every requirement set forth.

Description Proceedings A. R. M. M. A., 1910, Volume XLIII.

BARNUM UNDERFEED STOKER.

This machine is in the process of development and so far has been used as a distributor only, requiring coal to be shoveled into the hopper.

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The reports from the Chicago, Burlington & Quincy Railroad indicate that the mechanism operated satisfactorily burning an inferior grade of fuel, showing economic results. It is in successful operation on a six-wheel switch engine and a Prairie type freight engine.

A method of crushing coal on the tank and delivering it to the hopper on the engine is now being developed which will make the device meet all the requirements enumerated.

STROUSE OVERFEED STOKER.

Described in Proceedings A. R. M. M. A., 1909, Volume XLII.

Your committee is not able to report fully thereon.

The manufacturers have increased the scope of the apparatus, which formerly consisted of a distributor only, by adding a conveyor from tender.

Satisfactory service has been obtained with regular crews, but the development to date does not permit of complete report.

STREET OVERFEED STOKER.

Described in Proceedings A. R. M. M. A., 1910, Volume XLIII.

There are ten machines in service, including four on the Lake Shore & Michigan Southern Railroad, one on the New York Central Railroad and the remainder distributed on five other railroads.

The stoker is designed to meet every requirement suggested by your committee, and is successful in its operation.

HANNA OVERFEED STOKER.

The stoker has been developed only as a distributor.

Consequently, it falls short of the requirements set forth, inasmuch as run-of-mine coal can not be handled, and shovelling from tender to a hopper is necessary.

The device distributes coal into the fire box very satisfactorily and is rendering good service on the Queen & Crescent Railroad, operating on Mallet, Consolidation and Pacific type locomotives.

For description, see Appendix " A."

HAYDEN STOKER.

The original design failed in two particulars, unreliability and poor design of conveying mechanism and the burning out of coal-distributing plate.

The modified distributor developed independently from the conveyor avoids the distributing coal plate in the fire box and is giving satisfactory service on the Erie Railroad.

DICKINSON OVERFEED STOKER.

This is a further development of the principle involved in the Hayden stoker and seeks to fulfill the requirements of your committee.

It is in operation on the Erie Railroad and giving satisfactory results in regular freight-train service.

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BREWSTER UNDERFEED STOKER.

One of the above was recently applied to a locomotive on the Erie Railroad, but owing to modification being required the time was too limited to permit of the results being included in your committee's report.

The stoker is designed to meet all requirements previously mentioned. For description, see Appendix "B."

SUMMARY REMARKS.

This report does not include any tests comparing efficiency of mechanical stokers to hand firing, as your committee believes that mechanical stokers must be made flexible and reliable machines before any prospects of improved economy in fuel consumption may be expected.

Tests comparing inferior fuel used with mechanical stokers to regular supply for hand firing, thus taking advantage of difference in present fuel values, should not be accepted as proof of economy, as such relations would not maintain with the extension to any appreciable number of mechanical stokers.

The progress during the past year has been sufficiently marked to lead your committee to believe that it can present a final report at the next convention upon at least several of the stokers which have already been developed sufficiently to perform actual continuous service.

Respectfully submitted,

T. RUMNEY, Chairman,
E. D. NELSON,
C. E. GOSSET,
J. A. CARNEY,
T. O. SECHRIST,
Committee.

NEW YORK CITY, June 1, 1911.

APPENDIX "A."

DESCRIPTION OF THE HANNA STOKER.

The Hanna stoker is a coal distributor of the overfeed type, using steam jets. The coal is shovelled into a hopper and then pushed up a conduit by means of a short screw. From the conduit the coal falls over a ridge plate onto the fuel-distributing plates in front of the steam jets. Two wings move over the ridge plate in such a way that the coal is distributed in a cycle over the grates. These wings are also adjustable so that coal may be concentrated on any portion of the grates. They are actuated by a set of levers, connecting rods and ratchets from the main shaft of the stoker. The motive power is furnished by a small two-

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cylinder reversible engine. The entire device is self-contained and bolts rigidly onto the back boiler head of the locomotive.

No mechanism is provided to crush all classes of coal or to convey the coal from the tender to the hopper.

APPENDIX "B."

THE BREWSTER STOKER.

Consists in part of a screw which is placed in the bottom of the tender and covered with movable steel plates, so arranged that a gradual flow of coal is admitted to the screw. The coal is conveyed by means of this screw through flexible coupling to a point below the grates. It is then carried upward through the grates by means of a second screw to the steam jets which are on a level with the bottom of the fire-box door. The blasts from the jets, which work intermittently, are adjustable to meet any condition of fuel or size of fire box.

The grates are divided into four divisions, two on each side, and by means of a cam — one section at a time — they are tilted slightly forward to advance the fire and agitate the grates sufficiently to keep clear of ashes.

The whole arrangement is operated by a small double-cylinder engine, located on the left side of the locomotive, below the cab.

THE PRESIDENT: Gentlemen, you have heard the report of the Committee on Mechanical Stokers. If there is no objection, the report will be accepted and opened for discussion. Do any members desire to discuss this paper? This is a subject you have all got to come to sooner or later with heavy engines. There are a number of gentlemen in the room representing roads which use the stokers, and we would like the have the benefit of their experience. The Burlington Road is using the Barnum stoker. If Mr. Young is in the room we would like to hear him tell us what he can about that stoker.

MR. C. B. YOUNG (C. B. & Q. R. R.): There is really nothing that can be said with reference to this stoker further than the information given in the report of the committee. For perhaps four months we have had the stoker in successful operation on switch engines in Chicago, and it has produced no smoke; it has burned inferior coal and it operates as well and as cheaply as other switch engines of the same class. The road engine has not been quite so successful as the switch engine, but has been doing pretty good work, and we are now developing for the road engine

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some modifications, embodying slight differences, which are necessary from the application of the stoker to the switch engine. Beyond the fact that the stoker is really a good stoker there is nothing further to be said.

MR. BENTLEY: I suppose the stoker has been put on the switch engine just to keep close observation of it and to enable you to watch its performance and remedy any defects that might occur, but it seems to me a switch engine is not a desirable engine upon which to put a stoker.

MR. YOUNG: The stoker was put on the switch engine to avoid the smoke nuisance in Chicago, and it is doing it.

MR. G. A. HANCOCK (St. L. & S. F. R. R.): I should like to relate an experience with the stoker on the St. Louis & San Francisco Road with the Mallet engine. It meets the requirements of the committee. The fuel economy is about in line with the report of the committee. The whole economy depends entirely on the fireman. The conveyor apparatus is entirely satisfactory. We have been troubled with the crusher, but that is on account of foreign substances, such as stone and slate; but outside of that, with the heavy engines, it is far superior to hand-firing, and the firemen after becoming experienced in the use of the stoker become very expert in its use and bring about very satisfactory results. I think it will be easier on the flues. It is what we want for a heavy Mallet engine.

MR. GAINES: I would like to ask if there is any one here from the Queen & Crescent Route? They have the Hanna stoker on their road. I had occasion less than a year ago to send two of my road foremen there to spend three or four days in observing the operation of the Hanna stoker on that road, and these men made a very favorable report on the action of the stoker on one of the Mallet engines, and if there is any one present who can give a further report regarding the operation of the stoker on that road, or the operation of the Hanna stoker on any other road, I think it will be very interesting.

MR. T. O. SECHRIST (C. N. O. & T. P. Ry.): Referring to the performance of the Hanna stoker on the C. N. O. & T. P., I will say that we have eight engines equipped with the Hanna

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stoker complete. One of these engines, a Mallet compound, has been equipped for fourteen months, and during that time we have had two failures. These failures were due mostly to the carelessness of the crew assigned to the engine, but during all the rest of the trips this engine has made, the performance of the stokers has been entirely successful and satisfactory. We have had at least twenty-four representatives of foreign roads riding on this engine. The same thing holds good in case of the Pacific type engine, and consolidated type engine equipped with the Hanna stoker.

However, it does not meet with the full requirements set forth by the committee as it does not convey the coal from the tender to the fire box, but that will be a very simple matter to arrange, to equip the stoker along those lines.

As far as the stoker being a distributer, I differ a little bit along those lines with the other members of the committee. I think the stoker can be classed as a stoker only, and just as I have said, the conveying and crushing part is only a small matter to apply in conjunction with the stoker.

On the trip from Oakdale to Danville, Kentucky, which is an extremely mountainous country, with grades 60 feet to the mile, and curves of six per cent, as some of the representatives who had ridden on the engine will bear me out, at some points on the road you can not see the caboose, and notwithstanding these conditions, at no time have we failed on account of steam on any of the engines equipped with stokers, and at the end of 137-mile run you can look into the fire box and find it perfectly level; there are no ridges, not high in one spot and low in another. Any time we have trouble with the draft-blast, say when we run the engine out of the shop and the engine burns more coal around the flue-sheets, we can overcome that by adjusting the steam blast which is equipped for a high and low pressure blast. The same thing applies to the back end of the fire box, in case the engine burns too much fuel there, or burns too little, and the representatives of the railroad who made trips on this engine will bear me out fully along these lines. The Mallet engine consumes about 6,000 pounds of coal per hour, while the consolidated engine will run

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along about 4,500 pounds, and the Pacific type of engine will run about the same as the Mallet.

I do not think the requirements set forth in the report of the committee, on account of the crusher and the conveyor, should interfere very much with the handling of the stoker, but I would not want a wrong impression conveyed to the members of this Association along those lines. However, I am not here to criticize any reports made by the committee, as I think the report is very commendable. We have a number of gentlemen present, I believe, who have visited our railroad and ridden on engines equipped with these stokers, and I would like to hear from them.

MR. GEORGE L. FOWLER (*Railway Age Gazette*): I had the pleasure of riding on one of the engines on the C. N. O. & T. P. Ry. the other day, at Mr. Sechrist's invitation, from Oakdale to Somerset. We had the full tonnage and the engine was of the consolidation type. We hauled about 920 tons, up a 60-foot grade, and, in one case, I think, we ran 5 miles up such a grade from the start to the stop in 11 mintes. The remarkable part of the run was this: the engine was not only kept hot during the whole period of the run, the safety valves opening at 210 pounds, and the steam never dropping below 195 pounds, but the fireman on the engine had made three round trips prior to that on a locomotive, and these three had been on this stoker engine. He had just qualified as a fireman and happened to be assigned to this trip. He knew nothing whatever about the stoker, and the only instructions he had ever received had been from his engineer in a desire to help him out. The man was so green that once when we stopped for water he asked the engineer what he was stopping for. But he succeeded, however, in keeping the engine hot during the whole period. A run of 137 miles was made. The last part of the run, from Somerset to Danville, with a tonnage of 1,200 behind the engine, the total coal consumed on the whole run was, I should estimate, about 14.5 tons, certainly not more than 15 tons. We had a tank not quite full when we left Oakdale, and we took on 3 tons of coal at Somerset.

I have ridden almost all of the stokers that have been put on the market, and it seems to be a comparatively easy thing to make a stoker that will keep up steam. I have seen the Kincaid stoker,

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the Hayden stoker, and all others, keep up steam under ordinary conditions, but it has been by the use of an excessive quantity of coal. I am rather inclined to think, personally, that a great deal of the excessive coal consumed by the present stokers on the market is due to the fact that it is such an easy thing to put coal in the fire box. The fireman has been educated to shovel coal and work hard, and when it comes to taking a shovel and sliding the coal into the crusher, as he does on the Street machine, or shoveling it with little effort into the hopper, as he does in the Hanna machine, it is such an easy job that he naturally puts in more coal than there is any necessity for his doing. There is another point; the firemen have had practically no instructions whatever in the care of the stoker and what is necessary to do to keep up steam, so that these two points combined lead me to the conclusion that it is a comparatively natural thing for them to put in more coal than there is any necessity for them to do.

There is one point the representatives of both the Street and Hanna stokers insist on very strongly, and their insistence is apparently well founded, and that is, that the coal should be proper coal for the stoker, not necessarily selected coal, but that it should not have large lumps in it. The stokers do not handle heavy, lumpy coal with the same facility that they do the crushed coal. Mr. Street put a crusher on his tender and it crushed the coal so that the coal is always fine when it goes into the stoker. Mr. Hanna does not do that, but asks what they call on the Q. & C. Road, "Stoker coal" — that is a fine coal. Slack coal should be used.

We noticed the very marked difference on that run from Oakdale to Danville, in the case of the coal we took on at Somerset. The coal put on at Oakdale was a fine coal, and during the run to Somerset, 117 miles, the fire was just as smooth and as flat as could be desired — it was burning beautifully. The hook was not used, nothing was done, the stoker was not altered, there was no change in the distribution at all, the firemen simply put the coal into the hopper and it went into the fire box. The only change that could be observed was that the safety valve occasionally opened, when the engine was working the hardest on the grades, but the moment we got to Somerset, and fresh coal was taken on,

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they put on two buckets of the fine coal like that which had been taken on at Oakdale, and one bucket of the coal taken on at Somerset, which was rather lumpy, and the moment the lumpy coal was put into the fire box, the blast was not strong enough to throw it to the front, and the coal banked up against the back sheet, so that in the next few miles it was necessary to use the hook three times. The moment the lumpy coal was disposed of, the fire flattened out and there was no trouble whatever after that.

In adopting the use of the stoker, there are some things which should be looked to carefully. The first thing I would mention is that the men should be given some idea of what they are going to use, what the stoker is for, how it works, and then have the roundhouse forces take care of the stokers. There seems to be an idea that the stoker is a machine and will take care of itself, just as the man takes care of himself, and needs no particular attention. This, of course, is a mistake. The stoker, like any other piece of machinery, requires proper attention to keep it in working order. The other point which I would make is to give the stoker the proper kind of coal, and if you do that, with any of the three stokers now on the market, there is no reason why an engine should not be fired perfectly. Under these conditions, it seems probable that the firing can be done more economically with the stoker than it can be done by hand firing.

MR. SELEY: Will Mr. Fowler tell us something about the smoke characteristics of the stoker?

MR. FOWLER: I observed the smoke very carefully. I did not have a Ringelmann chart out on the smoke box, as I wanted to have, but my judgment would be that the smoke runs between 2 and 3 on the Ringelmann chart, when the engine is working heavily and the fire is being constantly fed by the stoker, but the moment there is any let-up the smoke drops down to practically between 1 and 2, if not down as low as one, on the Ringelmann chart, which is practically clear. But there is smoke, and constant smoke, with both the Street and Hanna stokers when they are working heavily; but in meeting other engines not equipped with the stoker, there seemed to be a very marked difference between the smoke coming from the stacks of the stoker engines and that coming from the stacks of the engines

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not equipped with the stoker, that is, the smoke from the engine equipped with the stoker was very much lighter. I should judge, on the ordinary engine, with hand firing and working hard, the smoke would run between 3 and 4, while with the stoker engine it was between 2 and 3, perhaps nearer 2 than 3, though, of course, this apparent difference may be due, in part, to the difference in the point of view from which the observations were made.

MR. C. E. CHAMBERS (C. R. R. of N. J.): It was my privilege a short time ago, through the courtesy of Mr. Crawford, to make a trip on one of the Pennsylvania engines equipped with a Crawford stoker We had a tonnage train of coal cars, there was no hand-firing done at all and almost no smoke — there was but little smoke perceptible—except just when the stoker was put into operation, and at that time there would be a discoloration of the steam coming from the stack, but not anything that you would term smoke, such as would come from a soft-coal engine. It was about the most gentlemanly job of firing I ever saw; a man could wear a white shirt. The only evidence that anything was going on was the disappearance of the coal in the center of the tender. It was not visible above the deck line.

As to steam pressure, if I had not seen the engine stand still, I would have thought that they had fixed the pointer for the steam gauge. I could not see that it varied from 205 to 206 pounds at any time. There was not one hitch during the entire time that we were on the engine — there was nothing at all occurred which could be considered as unfavorable to the operation of the stoker, except that possibly once or twice the coal blocked in the chute temporarily, by reason of some lumps coming in, that the crusher had to get rid of, but that did not amount to anything at all. The tonnage was 1,700 or 1,800, but that was not anything of special note, because they said it would be the same thing with 3,500 or 4,000 tons. The engine was really a remarkably even steamer for the heavy tonnage. I thought it was miraculous. The performance of the engine during the entire trip excited my greatest interest, and I was very glad to hear Mr. Fowler say something about the smoke from the overfeed stoker, because I had not seen the overfeed stoker in operation.

MR. FOWLER: I believe at the meeting last year I gave some

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memoranda in regard to the operation of the Crawford stoker, and that was the reason I did not speak of it this morning. I think at that time I compared the smoke coming from the Crawford stoker to the average conditions of the Pittsburgh atmosphere — the smoke would not be distinguishable if the engine were running through Pittsburgh. I rode the engine from Pittsburgh to Crestline, and there was no smoke whatever. When I returned I was asked how the steam pressure ran, and I said I did not know; I thought they must have been monkeying with the gauge because the pointer did not move throughout all the trip, and that is simply in corroboration of what has already been said.

MR. E. W. PRATT (C. & N. W. Ry.): I think in all fairness to the Crawford stoker these remarks about the Pittsburgh atmosphere should be omitted.

MR. D. F. CRAWFORD (Penna. R. R.): As we look on the stoker which you kindly refer to as the Crawford stoker, as a development rather than an invention, I think the Association will probably pardon me if I say something about it. We have made, all told, with this type of stoker 2,000 trips. Of these, about 1,600, representing very roughly 160,000 miles, have been made with what might be called the later developments of the stoker. There are at the present time about twenty locomotives equipped. There are nineteen in regular service and we have ten or twelve more under way. The stokers have all been applied, with the exception of three, to what we know as H-6 type of consolidation locomotives, having 49 square feet of grate surface and a calculated tractive power of 40,000 pounds at eighty per cent steam pressure. Two of the machines are placed on a larger consolidation locomotive and one on a switching locomotive.

The stokers up to three or four months ago were in the hands of regular crews, and in some cases a man riding with them, that is a stoker instructor, a fireman who had been taught what the different parts consisted of and what was expected to be done with them. It was his duty to teach the other firemen how to handle the stoker. About three or four months ago five or six of the locomotives were assigned to one division and were turned over to "the pool," that is, the enginemen running first in and first

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out, taking the engines as they came. Out of 1,524 trips the latest stokers have made, about 915 of them have been one hundred per cent stoker-fired; that is, no coal was put in by the shovel at all. A total of 1,178 have been ninety per cent or over, and the average of all trips is somewhere about ninety per cent.

The stoker has been in use at the testing plant at Altoona. We have made a number of tests with Salineville coal, which is used regularly, and we have succeeded in firing on 49 square feet, which is reduced to 33 square feet by the application of the troughs up to 6,300 pounds of coal per hour. We have fired that amount successfully and maintained steam pressure with it and the performance was in every way satisfactory. I agree fully with the conclusions of the committee as to the desirable points of a locomotive stoker. I disagree with Mr. Sechrist, who said that the conveyor should not be used. The stoker is not complete unless it does the complete work of handling the coal. The first stokers we had were without the conveyor, and they did not appeal to me as meeting the situation.

Something has been said about coal economy. From the indications obtained on our testing plant I think with the equivalent of the open-grate area the results will be as good, or even better, than those obtained with the best hand firing. On some of the tests made the stoker has shown conclusively that it will save coal as compared with the average hand firing. However, I do not look to coal-saving in itself as being the most important point of advantage of the stoker. To me the important point is to be able to rate a locomotive not on the size of the cylinders, but on the pounds of coal that it burns. Our consolidation locomotives are probably using in regular service over a continued run in the neighborhood of from 3,000 to 4,000 pounds of coal. I want to rate these locomotives at 5,000 pounds of coal, and make the train behind the locomotive a 5,000-pounds-of-coal-per-hour train, and do what such a train ought to do. It is not necessary to build any heavier or larger locomotives, but burn more coal and use the existing locomotive up to the capacity its adhesive ratio will permit.

As to smoke. One of the consolidation locomotives with the stoker is in switching service in one of the large cities where they

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have a smoke inspection bureau in operation and has been for some years, with very well-trained observers. I had the privilege, if I may so term it, of having one of their trained observers take notes and make observations on this engine at different times for a period of forty hours. He made a total of 9,754 smoke observations, of which 9,150 were No. 0; 569 were No. 1; 21 were No. 2; 10 were No. 3, and 4 were No. 4, on the Ringelmann chart. The average smoke, as the gentleman calculated, was 1.5. In other words, 98.5 per cent of the smoke was eliminated on this locomotive while in switching service. Mr. Fowler's run was 189 miles; that was the regular service of the engine, and it was practically smokeless. Mr. Chambers' run was a much shorter one. One difficulty that we have found is this: West of Pittsburgh we use the Ohio coal. East of Pittsburgh we use some coking coal, and we have had some little difficulty with it. We expect to overcome the difficulty, however, and are working now to do it.

THE PRESIDENT: I will be glad to hear from some of the other members on this subject.

MR. C. F. STREET: I have put ten of these machines in service. Of course, it has been a question of gradual development. The machine I have here on the pier on exhibition I will say frankly is the only machine I have ever built with which I am thoroughly satisfied. The other machines are all subject to improvement.

There are two or three matters in connection with the general stoker situation that I would like to bring up. The first is this: You put a stoker on your locomotive. The main object is to increase the capacity of the locomotive. As Mr. Crawford has said, the capacity of firing is about 2½ to 3 tons per hour. With the stoker you can jump up to 5 tons of coal per hour. Now, with that increased capacity you at once increase your tonnage. The master mechanic of one road where my stoker is running told me that if they equipped their locomotives with that machine he would be able to increase the hauling capacity of the locomotives from fifteen to twenty per cent. Gentlemen, that is the key to the whole proposition. You get a stoker that will do that, and

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the question of fuel economy becomes immediately secondary. You can afford to burn considerable more coal. Another point is the increased speed that the locomotive is able to attain. They will climb a grade that is unable of accomplishment with hand-fired locomotive. Therein is the great advantage of the stoker. Another thing, and it is a most difficult part of the whole stoker proposition: I can put any kind of a stoker on a locomotive and it will go along at a speed of 20 to 30 miles an hour, with any kind of tonnage, and work like a watch. Load the locomotive down with all it can haul and bring it up to a grade and come down to slow speed of from 5 to 8 miles an hour, and work satisfactorily. It is A, B, C unless you can keep your conditions within a reasonable range. The first time I got up a 30 or 45 or 60 minute run at 5 miles an hour I made up my mind that I did not have any stoker at all. There is the test of your stoker, and that is what your stoker will have to do. You give them a high speed, and then is when you want them to show good results. The passenger proposition for a stoker I have not tried out yet, but it looks so easy that it seems to me a shame not to do it because the conditions are ideal.

I do not think there is any question but that the scatter type of stoker will do. I think by applying the scatter type of stoker in firing it will eliminate a great deal of the smoke. But a great part of the trouble is, gentlemen, that your firemen are not given full and definite instructions as to how to use a stoker. There is not a piece of machinery you can think of that you put into the hands of a man to operate that you do not give him some sort of instructions as to its use. I have put stokers on where the fireman had never seen one before. Of course, you furnish him a pamphlet descriptive of the stoker, but how many of the firemen read it? These men should be given full instruction. You would not think of putting a man on a train to handle an air brake without giving him instructions. Look at the schooling you put your engineers through before they are allowed to run a locomotive. It is going to be necessary to have some man, or to have a department, or a set of men, who shall make it their business to instruct the firemen in the proper handling of the stoker.

The question of whether the crusher shall be on the tank, or

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not, I think is very material. I am building a machine now that will take the coal by a conveyor from the tank, and put it into the fire box without the use of a crusher.

As to the quality of the coal: I made up my mind that a stoker in order to be successful would have to handle any quality of coal that was given it, and take anything from poor slack up to the best lump coal. Right on this point I want to read to you an excerpt from a letter from a railroad company that had a man on an engine watching the operation of the stoker:

> We received 1,700 pounds of coal only five per cent lumps; the slack composed mostly of sand and mud, and we could easily make a mud ball of this coal, but still the engine did well on it.

[Laughter.]

Gentlemen, that is the sort of coal we are asked to fire locomotives with, and we are doing it. [Laughter and applause.]

As I began, so I will close. The key-note of this whole question is increased tonnage and increased speed. On a time freight we put the schedule of an hour and thirty-five minutes over a division where it was difficult to make the time with a hand-fired locomotive, and we did it.

THE PRESIDENT: I think it would be well to hear from some members who are using the Strouse stoker. We had some very nice reports about this stoker two years ago, and I have been wondering whether there were any new developments in respect to it. Is any one here who has had any experience with this stoker?

MR. M. H. HAIG (A. T. & S. F. Ry.): I did not intend to have anything to say on this subject because my experience does not justify a comment as complimentary as remarks made by the several members who have spoken. Since I have been called upon, however, I will explain briefly what the experience has been with mechanical stokers on the Santa Fe Railway.

This railway company has applied three types of stokers to three Mallet locomotives of the same design. The locomotives have cylinders 24 inches and 38 inches by 28 inches, 69-inch wheels and tractive force of about 68,000 pounds, and operate through a territory in which the ruling grade is about six per cent. Every opportunity has been given to the stoker representatives

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to instruct the firemen. I feel that this statement to a certain extent covers the point mentioned by Mr. Street concerning the necessity of giving full instructions as to the use of a stoker. The stoker manufacturers have had an opportunity to instruct the men and the road foremen have given a great deal of attention to this instruction.

Mr. Fowler presented an argument with which I can not agree. He claims that the coal should be selected to suit the stoker. I do not regard this as practical. The stoker should be selected to suit the coal common to the territory through which the road passes.

The three stokers that have been placed in operation on the Santa Fe are the Hanna, the Street and the Strouse. By hand-firing, the locomotives to which these stokers have been applied consume about fourteen tons of coal per hundred miles. They haul about two thousand tons, largely in refrigerator cars, and it has been found that with the stokers, especially the Street and the Hanna, they require from 18 to 20 tons over the same territory. The two stokers just mentioned have made comparatively few trips without having to run for coal.

The Strouse stoker has been more successful in the matter of economy. However, the firemen claim that they have to work as hard using this stoker as they did in firing by hand, because of the labor required in lifting the coal to the hopper. The Strouse stoker is a noisy appliance and, therefore, not a very pleasant device to have in the cab; but it has done the work.

The principal trouble so far encountered with the Hanna and Street stokers has been in banking the coal near the back end of the fire box. This has frequently made it necessary to cut out the stoker after going over a portion of the division and fire by hand over the remainder of the division. Some difficulty has been experienced also as a result of fine coal being carried through the tubes and out of the stack.

To answer the comments on providing suitable coal: At the request of the Hanna representative, different kinds of coal were provided. Objection was raised to the lumps in the usual run of mine coal and slack coal was requested. To adapt conditions to suit the stoker as a matter of trial, slack coal was shipped to

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the territory in which the stoker was in service and with the slack coal the fire banked under the door. It is possible that this banking may have resulted from an improper adjustment of the device, and it is hoped that further experiment might result in overcoming this condition.

MR. J. F. DEVOY (C. M. & St. P. Ry. Co.): I have just completed a year's experience with the Strouse stoker, and I have nothing complimentary to say about it.

I agree with Mr. Crawford that a conveyor is an absolute necessity for the reason that it will lessen the work of the firemen. Firing on an engine with a stoker the fireman has to lift the coal 2 feet 2 inches from the depth of the fire door, and with a stoker he lifts it 3 feet and 3 inches. The actual work involved in lifting the coal, therefore, is fifty per cent more when firing with a stoker than when firing by hand. It is on this account that I take the position that a conveyor on any sort of a stoker is an absolute necessity.

My real object in rising to speak at this time, however, is to question the Ringelmann chart system. In Chicago it is almost an absolute impossibility to live up to the smoke law. I would make the request that the committee, if continued, shall define and state whether or not the Ringelmann chart shall be used in judging as to the smoke from a locomotive. I take the position that it was never intended to be used for any such purpose; that it was gotten up originally by an eminent engineer for the purpose of judging a smoke from a factory stack, in which there was no mixture of steam, and that it should only be used for that purpose. I take the position that the greatest amount of smoke emitted from a stack is usually at starting the work of the engine; that the greatest amount of steam is mixed with the smoke when the greatest amount of work is done, or when the greatest amount of coal is being burned. Therefore, the Ringelmann chart is misleading in judging the smoke or the color of the smoke emitted from a stack, due to the fact that you are judging seventy-five per cent steam and not smoke.

I have no objection to the reference made by the gentleman, for the reason that if I did make that objection I should want some logical way by which smoke could be judged, and there is

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none to-day other than the Ringelmann chart. I think the committee should define as to what per cent and at what time the Ringelmann chart should be used, for it is misleading, and if you follow it up you will find it to be so.

As to whether a stoker will save coal or not, the results of our one year's experience show us that hand-firing saved nine per cent in coal economy over firing by a stoker.

MR. STREET: May I ask the gentleman a question there. Was the matter of speed taken into consideration at all? You say that by hand-firing you save nine per cent in coal. Was the speed at which the machine was operating taken into consideration in arriving at that conclusion?

MR. DEVOY: My remarks in regard to that are based on our experience of twelve months in which an exact record of the coal consumed was kept; the average performance of the locomotive in both directions over a single division. The figures were 10:71 pounds for the stoker-fired locomotive and 10:54 pounds for the locomotive not equipped with a stoker, per 100 ton-miles. Does that answer your question, Mr. Street?

MR. STREET: I was not paying attention to what the gentleman was saying.

MR. DEVOY: Well, there is no use having a scrap with a man if he doesn't pay attention to what you say.

As I said before, my principal thought in rising was to call the attention of the committee to what I believe to be an absolute necessity, namely, to have a definition as to the use of the Ringelmann chart. In my opinion, it has been applied to a case on which it has no bearing whatever.

THE PRESIDENT: We will be glad to hear from Mr. Hayes. Mr. Hayes, you know something about stokers.

MR. W. C. HAYES (Erie R. R.): Mr. President and gentlemen: I was in hopes that I could duck behind some of the big fellows here and get out of sight on this subject. However, as you have called upon me, I will say that my views on this subject have changed somewhat from those I expressed at the last convention. Many of you will doubtless recall that I said then that I did not think stoker-firing could be compared in any way with

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hand-firing, especially from the standpoint of fuel economy, and that if railroads were willing to expend the same effort and expense in educating the firemen that they did in attempting to develop a successful mechanical stoker, better results would be obtained which would more than overbalance anything that could be secured from mechanical stoking. Since that time the development of the stoker on the Erie Railroad has brought about a change in my opinion, and I think now that perhaps stoker developments on the Erie Railroad are on the right track to enable Mr. Rumney to say that he will be able to complete his report in a satisfactory way to this Association by the time of the sitting of the next convention and show a stoker that will deliver the goods. However, I am sincere in the opinion that we should not let up on the education of the fireman in a good system of firing by hand, and carry that along together with any development that may be made in mechanical stoking.

MR. PRATT: I would like to ask those who have had most experience with mechanical stokers what is the low limit per hour in the amount of coal to be supplied the fire box? What would they recommend in that respect? Would it be 4,000 or 3,000 pounds per hour? Below what point would they consider it inadvisable to apply mechanical stoking?

THE PRESIDENT: I think Mr. Crawford has worked on that point.

MR. CRAWFORD: I have not worked on the low limit. I have been working on the high limit, trying to "high it" all the time. As I understand Mr. Pratt's question, he asks whether it would be economy to put a stoker on a locomotive using a comparatively small quantity of coal. We have not, because we do not expect to have small locomotives in service, excepting, perhaps, small switching locomotives, where we would apply the stoker from the smoke preventive viewpoint. In all the cities through which our lines run there are now smoke ordinances. I would not recommend putting a stoker on a light passenger locomotive at present as I do not think that there would be any gain from it other than eliminating smoke. But, as I said, we are not thinking of the low limit at all. We are trying to increase the power of the locomotive by supplying ample coal.

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MR. DEVOY: In reply to Mr. Pratt's question, I would like to say that the daily record of our trains that I referred to shows a consumption of 3,500 pounds of coal per hour. This is equivalent to 72 pounds of coal, per square foot of grate, per hour. I think Mr. Pratt's question should be taken up by the committee.

MR. BENTLEY: I think Mr. Steele is in the room, Mr. President, and he has had a great deal of experience in determining how much a fireman can handle.

THE PRESIDENT: Mr. Steele, we would be glad to hear from you on this subject.

MR. STEELE (American Locomotive Company): I do not think I can say anything of interest on this subject at the present time. I do feel, however, when the maximum coal consumption is about 5,000 pounds of coal per hour, the use of a mechanical stoker equipped with a conveyor is an advantage, as it not only greatly reduces the fireman's labor, but in most cases permits of increasing the work done by the locomotive.

THE PRESIDENT: I would like to hear from Mr. Gossette, of the M. & St. L. Road, on the Strouse stoker.

MR. C. E. GOSSETTE (M. & St. L. R. R.): Mr. President and gentlemen: As stated in our report, the Strouse stoker will fire a locomotive and it will do it well when it is working. [Laughter.]

Like the experiences of a former speaker, we have had numerous troubles due to its failing. I regret to say that we found it necessary to discontinue our further experiments with the machine because of the number of failures experienced. While we had the stoker in the hands of a regularly assigned engine crew who were thoroughly familiar with its different parts and knew how to take care of it, we obtained very good results, but when the machine was turned over to a pooled or chain-gang crew, our troubles began, and finally they became so numerous that we discontinued our experiments some seven or eight months ago, and at this time we have no stokers working.

THE PRESIDENT: This is a live subject, gentlemen, and this is the place to state your experiences. I hope you will let us have them, and give us the benefit of anything you have observed.

MR. HAIG: I would like to ask some questions of the gentle-

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men who say they have operated these stokers successfully. Have they ever had any trouble with the Hanna and Street stokers banking the coal under the door? Have they ever had any trouble with particles of the coal being carried through the flues and out of the stack? I would also like to ask whether they can give us any information concerning the coal that was used; whether they had to provide a special quality of coal? In the case of the Street stoker, I do not think it is necessary to provide a special coal.

MR. SECHRIST: We use, when we can get it, the regular nut and slack. We take by preference about ninety per cent of slack. At times we have to take coal when we are unable to get the slack at mountain stations. The crews prefer the slack coal, as they claim that makes them less trouble.

As far as the carrying of fine particles of coal through the flues is concerned, I believe that is all due to the handling of the blast. If you use high-pressure blast, of course, you can carry fine particles of coal through the flues and out the stack. We at first had that trouble, but we have overcome it, and I have not heard a word of complaint on any engines that we have now equipped with a stoker.

As to the banking of the coal around the fire door, we have not experienced any trouble on that line. I have made at least one hundred trips with the stoker and have not observed any trouble of that kind. I think that may have been due to the regulation of the blast. Only on one occasion do I remember any complaint of that kind, and the trouble there arose because the draught sheets were not rigged properly. We overcame that trouble by adjusting them differently.

MR. J. CHRISTOPHER (T. H. & B. Ry.): I would like to ask what is the experience of those using the stoker as to the front end filling up, as compared with hand-firing. I would like to know whether it becomes necessary to clean out the front end more frequently or not?

MR. SECHRIST: We have been using the stoker for the past fourteen months, and at first we did experience that trouble. We have had no trouble along that line lately. We have not had any occasion to inspect engines on account of the filling up or on

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account of coal being drawn through the tubes, and we have watched that matter pretty closely, thinking that perhaps coal might bank up around superheated pipes.

MR. HANCOCK: Regarding the Street stoker, I would say that we have had a great deal of trouble of the same nature that Mr. Haig spoke about. I think possibly ten per cent of the trouble is caused by faulty firing, and the minute the fireman becomes accustomed to the stoker it works better. We have had some smoke trouble on heavy service, but on light service it has been comparatively small.

MR. STREET: I would like to answer Mr. Haig's query regarding coal going through the flues to the stack. On my first machine I had a great deal of trouble with the coal being carried through to the stack unconsumed. As I said before, the first machine I ever built is now here on the pier, and it has a screen for screening the fine coal out and depositing it across the back end of the grate where it does not get into the fire box. I have two of these engines working.

On the question of banking, I find with my first machine that the method I had adopted for dividing the coal in the fire box permitted of the locomotive, when going around a sharp curve and rolling a little on one side, banking the coal in on that side, and that when the engine went around the curve the other way it tipped the coal over to the other side. I have now put in a division across, so that the rolling of the locomotive has no effect on the distribution of the coal in the fire box, and I am arranging to rebuild the machines that I have out and put this device in them. The experience that I have had with these machines shows that the two points of difficulty pointed out will be entirely eliminated.

MR. ANGUS SINCLAIR: A very important point in locomotive operation is the condition of the flues. If the mechanical stoker has a tendency to cause more flue trouble than is experienced with hand-firing, or the reverse, why, it is very important. I think it would be very advisable to bring out that fact, if it is a fact. I suppose those who have had experience with stokers are able to tell whether there is less flue trouble, or more flue trouble, using mechanical stokers than there is in hand-firing.

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MR. SECHRIST: We have had no flue trouble with our stokers, but we have had with all our locomotives that are not equipped with mechanical stokers.

THE PRESIDENT: Does anybody else care to give us their experience, or to ask any question?

MR. CHRISTOPHER: I would like to have Mr. Crawford give us his experience with stokers and without stokers.

MR. CRAWFORD: I can only say that my experience is favorable to the use of stokers. We find very little difference between hand-stoking and mechanical-stoking, but whatever difference there is between the two is in favor of the mechanical stoker. Our flue troubles are not the flue troubles that we used to have. There is nothing like so much flue trouble or flue leakage to-day as we had formerly. I am not prepared to say whether it is due to the stoker or due to the different practice in our engine houses, but I am inclined to think it is due to the lâtter.

THE PRESIDENT: Now, I will ask Mr. Rumney, the chairman of the committee, to close the discussion.

MR. RUMNEY: I think practically all of the questions that have been raised by the various speakers, in regard to this subject, have been answered, but a few points will be referred to. Mr. Sechrist expressed the opinion that a conveyor is not necessary, and that it is a very small matter anyway. All I can say about that is, I wish we had found it to be so. We have been four years trying to get a conveyor, and we are only able now to say that we have a conveyor. I think Mr. Street has had some trouble, and I am sure from what Mr. Crawford has told me in the past, he also has had some trouble.

As far as economy is concerned, based upon evaporation per pound of combustible from and at 212° F., the mechanical stoker showed a loss of 1.055 per cent over hand-firing which, in view of the fact that stokers were then not nearly as perfected as at present, was considered a good showing.

The reference Mr. Crawford made to the rating is precisely the line upon which the committee has been viewing the question: That is, making the modern locomotive better and more powerful, and not seeking to economize in fuel consumption in order to

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make a good showing on a fuel basis, but figuring on a ton-mile basis, and on such basis, it is almost equal to hand-firing. In every case, the hand-firing was fairly good, and the stoker was a new appliance, consequently, the men were not as well trained in the operation of the stoker at the time of test as they were after they had handled it for some months.

All the experience with the mechanical stoker shows that there is very little smoke either with a scatter-type stoker, or the Street, or the Hayden, or the Dickinson type, which is practically the Hayden type, and it is known that the Crawford stoker is practically smokeless.

In respect to the comparison that has been made to the underfeed and the scatter-feed stoker: There might be some advantage in the scatter-feed type, in that the smoke would always be visible, and might be a guide to the fireman and enable him to check his work, but no decision has been reached in this particular. The matter, however, is worthy of consideration.

THE PRESIDENT: Gentlemen, the next subject is Revision of Standards. I believe Mr. Crawford has something to say on that subject.

MR. CRAWFORD: Mr. Demarest, of the Pennsylvania Lines, is chairman of this committee, but an emergency occurred during the last month which has prevented him from giving the subject his attention. I, therefore, apologize to the Association on behalf of Mr. Demarest, and I trust that you will all appreciate the emergency that has arisen and will accept the apology.

THE PRESIDENT: If there is nothing further to be said on the subject, we will pass to the next subject, which is a report from the Committee on Smoke-preventing Devices for Firing-up Locomotives at Terminals. Mr. Pratt is the chairman of the committee, and will present the report.

MR. PRATT: Mr. President and gentlemen, the report is as follows:

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REPORT OF COMMITTEE ON SMOKE-CONSUMING DEVICES, FOR FIRING UP LOCOMOTIVES AT TERMINALS.

To the Members:

On account of the laws and regulations of large cities, relative to the prevention of smoke, your Executive Committee appointed this committee to collect from the various members such information as might be obtainable with reference to the prevention of smoke during the critical period of time when locomotives are being fired up at terminals. That smoke prevention is extremely difficult at this time is evidenced by the fact that most large cities specifically exempt from violations the smoke emitted from boilers while being fired up.

Although only thirty-three roads replied to your committee's circular of inquiry, among these were included many of the largest companies and especially those having terminals located within the large cities where the restrictions are most severe; hence we believe this subject has been more thoroughly canvassed than might otherwise appear.

The various reports and the experience of the individual members of your committee would lead to the following recommendations:

BOILER CONDITIONS BEFORE FIRING UP.

First.— The best results are obtained by filling up locomotive boilers with hot water previous to firing up; the temperatures reported varying from 110° F. to over 200° F., the higher being preferred on account of aiding combustion and lessening the time required to raise steam in the boiler.

Second.— Where hot water is not available, the temperature of water in the boiler may be raised by injecting live steam below the water line; but on account of the loss of time, the heating of the water, either before or while the boiler is being filled, is recommended.

INDUCED DRAFT.

Third.— Two roads reported the use of large fans, connected with the smoke jacks above the roundhouse roof, as a means for producing draft. One of these roads advises that this device was used and tested for a considerable length of time, but was found unsatisfactory and abandoned. The other road is still experimenting along this plan in connection with a "smoke-washer," and is not yet ready to report upon its results except as to its difficulty in the maintenance of the plant — the metal parts having been eaten out several times during the year's experiments.

All other roads report the use of a roundhouse steam blower and the locomotive blower used exclusively.

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METHODS OF FIRING UP.

Fourth.— From the reports it would appear that almost every combination of wood, fuel oil, shavings, cobs, coke and bituminous coal had been used, with more serious objections to some than others. Several roads reported extensive trials of coke, but its use has been almost entirely abandoned because the ashes and gases emitted from the smoke jacks are much more objectionable than smoke when roundhouses are located near viaducts or high buildings; furthermore, it is almost impossible for employees to work in the roundhouse when engines have to be moved from under the smoke jacks to do necessary work, and also the cost of coke is greatly in excess of other fuels in most sections of this country.

While the smoke from wood varies considerably in accordance with the size, quality and amount used, still it is more generally employed for kindling fires than any other fuel where the greatest effort is being made to prevent smoke at such times.

APPLY BITUMINOUS COAL CAREFULLY.

Fifth.— The plan of raising steam to nearly working pressure by means of wood or coke alone has been tried by many roads, but abandoned when it was found that the same results could be obtained by adding bituminous coal carefully to wood fire after the temperature in the fire-box had been somewhat raised.

Sixth.— In general the conclusion is, that although there are many devices for reducing the amount of smoke from locomotives after steam is raised and engines are working, and while it is possible by great care and attention on the part of the roundhouse force to reduce the amount of smoke emitted during this period, at the same time we find no practical way to entirely eliminate all smoke while firing up locomotives at terminals.

Respectfully submitted,

E. W. PRATT, Chairman,
J. C. MENGEL,
R. W. BELL,
J. B. KILPATRICK,
E. F. JONES,
Committee.

CHICAGO, April 24, 1911.

THE PRESIDENT: Gentlemen, you have heard the report of the committee, and, if there is no objection, the report will be received and opened for discussion. This is a subject that we

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have all heard a great deal about, especially so far as it concerns the lines entering large cities where laws governing the emitting of smoke are in force. Mr. Manchester, can we hear from you on this subject?

MR. A. E. MANCHESTER (C. M. & St. P. Ry.): The recommendations of the committee are directly in line with our best efforts, Mr. President — the filling of boilers with hot water. The only point that they do not refer to, which is a factor that I believe adds largely to the result, is time. It is decidedly of advantage to take sufficient time so that the work of bringing an engine up to steam pressure is done slowly. We have found nothing better than kindling wood to start a fire with, a good liberal allowance of it, and then to feed the coal in slowly and have the coal well broken up as it is fed into the fire box, and use the force blowers to assist the fire to burn readily. If there is anything better than is indicated by the report of the committee it will be most satisfactory to have it thoroughly ventilated at this meeting, because it is one of the subjects that we are up against, and it is one of the most difficult propositions to control. With us, following these methods, we have found it largely a question of keeping our men up to their work and not let them hurry it. Just as soon as you begin to hurry the men, they begin to do the very things that produce smoke and cause trouble.

THE PRESIDENT: Mr. Henry, can we hear from you?

MR. W. C. A. HENRY (Penna. Lines West): Our experience, Mr. President, has been pretty much covered by what was stated in the remarks of Mr. Manchester. It is our practice in firing-up locomotives to make use of shavings saturated with oil. Where smoke is objectionable to the city authorities, we have resorted to the use of wood from the car repair yards for firing up. By using care and not trying to force the fire too much, we have been able to make considerable reduction in the quantity of smoke emitted, although there still is smoke.

MR. CURTIS: If the mechanical stoker is of any use in preventing smoke it has a good opportunity to show it now. I presume the mechanical stoker is not in operation, though, at the time of firing up. Still, I would ask Mr. Crawford or Mr. Street

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whether they do use it in the firing-up process, or whether the firing-up process is a hand-firing proposition?

THE PRESIDENT: Mr. Crawford, or Mr. Street?

(No response.) Mr. Young, can you answer that question?

MR. C. D. YOUNG (Penna. Lines West): In preparing a locomotive equipped with underfeed stoker, the same performance is followed as with hand-fired locomotives. It is our opinion that if a stoker were used to start the fire in the engine house considerable trouble would be experienced with the fire on the road.

MR. J. W. FOGG (B. & O. Chgo. Ter. R. R.): We are up against the same proposition Mr. Manchester referred to, and I think our best results have been secured in using kindling wood where you have the roundhouse men thoroughly drilled. If they get careless in the roundhouse, it does not eliminate the smoke nuisance. We have found if we use kindling wood and then apply the coal very lightly, we get good results. A good steam blower in the roundhouse will do good work eliminating smoke.

MR. CURTIS: For the information of the members, it might be well to note what we have done in the way of this smoke-washer. About eighteen months ago we equipped one of our roundhouses with a smoke-washing device which had been recommended to us by the smoke department of the city. This device consisted of a duct connecting the smoke jackets in the roundhouse through and to a fan, and from there to a large tube into which was injected a spray of water, and the washing of the smoke precipitated the carbon and made it very much less objectionable. We constructed these ducts of steel, and before we got the thing fairly installed or running more than six or eight weeks, the first duct was found to be entirely eaten out, due to the combination of the gases and moisture. We renewed the duct with wood. Then when we looked at the fan we found that the fan blades were eaten out and the fan housing had begun to go, and that the whole thing was practically a wreck. Therefore, we came to the conclusion that unless there is some other material that the duct and fan and fan-house can be made of, it would not do to recommend anything of the sort, because anybody going into

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the making of a steel duct and fan and connections would find them all eaten away because of this mixture of moisture and gases.

MR. ANGUS SINCLAIR: I have had experience with firing in my time, and I think I have paid more attention to smoke than most men have. When I was a fireman in Scotland many years ago we were subjected to much closer inspection than were the firemen in this country, and the raising of smoke was liable to get one prosecuted by the civil authorities. When I came over here I found that no attention was paid by firemen to preventing smoke, and in trying to instruct the men, whom I had as firemen, on smoke-preventing, the most of them fell into it very readily and found that by paying close attention to firing they could prevent a great part of the smoke. I wrote a book on "Locomotive Engine Running" many years ago wherein I gave considerable of my experience, and told how smoke prevention could be brought about, giving the simplest rules relating to the work. Some years later I was invited to attend some experiments that were being made as to smokeless firing on an Iowa railroad, which really followed the instructions which I have laid down on the subject in my book. The railroad officials knew what I had done on the prevention of smoke, and they endorsed it and introduced it generally and they made smokeless firing quite a success.

I wrote some articles for my paper describing the experience of that road on smokeless firing, and it may amuse you to know the effect on myself of these articles. They appeared toward the end of the year when renewals of subscriptions usually come into my paper, and then we calculated that we lost five thousand subscribers because of those smokeless-firing articles. It showed the sentiment of the time of the ordinary fireman and engineman generally regarding smokeless firing.

However, there has been great improvement since that time. The railroads have taken the matter up systematically and have trained their firemen in proper firing, which is really smokeless firing as far as it goes. In regard to this report to-day, I have had in the last few years rather embarrassing questions put to me owing to a booklet that I prepared comprising the articles referred to. It seems that it has been getting into the hands of municipal authorities and they got to sending me requests to tell them how

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to prevent the smoke from roundhouses that were said to be nuisances in certain cities. They thought that because I knew something about the principles of smokeless firing I ought to be able to tell them all about how to prevent smoke. I have uniformly made it a practice to answer that there are certain conditions under which smokeless firing is impracticable, and that is one of them. I do not know how you can prevent smoke entirely when you are raising steam in a locomotive.

I think the committee have done admirably in the report that they have made on how smoke can be reduced to a minimum in the very difficult process of raising steam from poor-burning coal.

THE PRESIDENT: Mr. Smith, of the Boston & Albany. We would like to hear from you.

MR. R. D. SMITH (B. & A. R. R.): I was interested in what was said this morning about the Ringelmann chart, but can not agree with the gentleman, because the Ringelmann chart has nothing to do with the making or abating of smoke. It is simply a chart by which the amount of smoke is measured, and, like a standard measure, there should be no objection to it. But about the terminal situation: we have tried out various ways of kindling fires in locomotives and have in all our important terminals hot-water washouts, and find the recommendations of the committee are about in line with what we have found best in our experience. A great deal depends on the fellow who is doing the firing in the roundhouse, and whether you are in a hurry for the engine or not. We object, however, to using old ties or old discarded wood, like old crossing planks, for firing of locomotives, because of the likelihood of spikes and nails being in it and getting caught in the grate and causing engine failure. So we try to keep away from the use of old wood unless it has been looked over carefully.

THE PRESIDENT: Mr. Bean, can you give us any information with regard to firing engines with oil?

MR. S. L. BEAN: We have very little trouble with the emission of black smoke when firing up engines in the roundhouses, especially when it is considered that we employ in our desert country, all classes of help for fire-builders, Japanese, Mexicans

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and Indians. We obtain very good results at our principal terminals. At Los Angeles we probably handle two-thirds of our power outside of the roundhouse, and by handling the atomizer carefully there is no trouble in preventing the emission of black smoke.

THE PRESIDENT: Mr. McCarthy, of the Big Four. Can we hear from you?

MR. M. J. MCCARTHY (C., C. C. & St. L. Ry.): The practice on the C. C. C. & St. L. Ry. is about the same as that recommended by the committee. It does not eliminate black smoke entirely. We find, however, that strict attention on the part of the men firing-up engines will do away with a very great percentage of the so-called black smoke.

MR. ANGUS SINCLAIR: I had some marine practice at one time. In firing up marine boilers a great deal of care must be taken not to have the fire started violently at first. The requirement is to heat up the boiler gradually and so prevent leakage. There is no question but what leakage used to frequently occur, and fractures, too, by reason of very violent fires being started up to begin with, as, for instance, when they sought to get up steam in a hurry.

Now, it just occurs to me that that trouble might be experienced with locomotives where you were firing with oil if you were to start the fire too violently at the beginning, and the query in my mind was whether it was not better for the sake of safety to fire up gradually.

MR. S. L. BEAN: I desire to emphasize that it is necessary to be very careful in handling the oil. If the atomizer is allowed to work too strong it will allow the oil to drip and there will be danger of conflagration through this source. In fact, since I left home we have had a roundhouse burn up with ten engines, due to this cause.

THE PRESIDENT: Mr. Chambers, can you give us any light on this topic?

MR. C. E. CHAMBERS: I do not know that I can, because there are very few places where we are restricted as to smoke in the firing of locomotives. In the heaviest terminal, which uses largely

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anthracite coal and where we use only a small amount of soft coal, we use kindling wood to start the fires. We use old ties for wood when we can get them, and have never had any trouble, as Mr. Smith spoke of, with the nails or spikes. We at one time used fuel oil, but for the last three or four years we have used gas tar, which is a by-product recovered from the manufacture of Pintsch gas. We use that for firing our locomotives, and we sometimes fire them with coal alone, and sometimes with wood. The former process makes a great deal of smoke, and where you are held strictly to account by ordinances aimed at the smoke nuisance, it is not so desirable, but in our locality we have had no trouble in any way on account of the firing of our locomotives.

Mr. F. H. Scheffer (N. C. & St. L. Ry.): We are having troubles in our section of the country on account of proposed ordinances prohibiting the emission of black smoke in firing-up and in handling locomotives inside city limits. The claim is made that the Chicago roads are handling this proposition very successfully, that they do not make any smoke in firing their locomotives, and I would be glad if some of the gentlemen in Chicago will give me information as to how this is done.

Mr. Gossett: I have read carefully and with much interest the report of the committee and listened to the discussion here this morning. I had not intended to have anything to say on the subject, but I have been sorely disappointed. I have watched the deal all the way through, and I have about made up my mind that the answer is not in the cards, as there seems to be no way possible that we can operate locomotives burning bituminous coal, without smoke.

The Minneapolis & St. Louis Railroad has its main shops, large roundhouse and switch yards located in the most fastidious neighborhood of the Twin Cities, establishing this location some thirty years ago. Since that time, Minneapolis has spread out until, at this time, the shops are almost surrounded with fine residences, and these residents are the ones who are raising the howl about smoke. In fact, only recently an ordinance was passed prohibiting the use of anything but smokeless coal. In firing-up our locomotives, we give our men as much time as possible and use principally wood.

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I have tried all manner of schemes I could think of or have seen in print, in order to, if possible, overcome this trouble and, as a result of this long experimenting, I have come to the conclusion that there are but two points that can be considered advisable; i. e., give the men as much time to get the engine hot as consistent, and use practically all wood for firing up the engine — the more wood, the less smoke.

THE PRESIDENT: Are there any other members who have anything to say on this subject?

MR. DEVOY: My experience has been the same as the experience of Mr. Gossett. I have attempted to handle the matter as nearly as possible in a personal way. I have made efforts by personal observation and inspection to get our enginemen to control the volume of smoke in firing-up by care with the method in which they do the firing. I have found no fault with the Ringelmann system, and I have stated to city inspectors when an engine passed by, under full head, working full, that in my honest opinion there was not ten per cent of smoke, and the inspector has called that steam.

I simply want this committee, or the other committee, to define how far the Ringelmann chart shall be used in connection with the locomotive.

I hope I make myself clear, now, because Minneapolis is the toughest place in the United States in regard to ordinances and regulations — it does not make any difference what it is. All you have to do is to go with an inspector once or twice and you will find that you will have to use the Ringelmann chart in order to determine how much smoke is coming from the locomotive. I would like this committee to make more definite recommendations in regard to the volume of smoke which is considered objectionable.

THE PRESIDENT: I presume, Mr. DeVoy, that if Mr. Pratt is still chairman of the committee, he will try to define that one question. Has anyone else anything to say? Mr. Bawden, can we hear from you?

MR. WM. BAWDEN (St. Louis Terminal): We are pretty badly up against this smoke proposition in St. Louis, especially

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on firing-up engines. We fire-up 125 engines right in the city, and the smoke question is a live one there at the present time. We find, however, that our experience is about in line with the report of the committee. We have not been able to find a way to eliminate the smoke during the firing-up of the engines. We have used old ties, generally with very considerable trouble, on account of the spikes and bolts and things of that sort. We have, however, a device which is being put into use called the Parson's System of Combustion, and we expect to eliminate the smoke to the extent of about fifty per cent. The Parson's System of Combustion is a very practical device on the road and eliminates from eighty to ninety-five per cent of the smoke.

MR. JOHN TONGE: Minneapolis at this time is undergoing a pretty serious agitation in regard to the smoke emitted from locomotives. They have had a law passed aimed to eliminate the smoke from locomotives in the city limits. They do not care how impossible it may be to eliminate this smoke — it is no concern of theirs, they say, how it is to be done, but they say that you must do it. I think I am right in saying that every railroad that enters into Minneapolis is subject to this ordinance, and that every railroad entering that city has now pending a lawsuit, the object of which is to set aside this ordinance.

I wish particularly to say that your expressions here will have considerable weight in these lawsuits which are pending, based on the Minneapolis ordinance, and the weight of your opinion will be in favor of the railroads. The representatives of the authorities go so far as to say that we should use smokeless coal, and if we use smokeless coal that we will eliminate the smoke emitted from the locomotive during firing. When any municipal body goes so far as to say you shall not use the natural State coal, it is going a little too far, even as a matter of law. I have no doubt that the railroads will follow this matter to the Supreme Court of the United States if the State Courts of Minnesota say that we must use smokeless coal in order to obviate this difficulty. The smoke inspectors are very arbitrary — they say they do not care what railroad is concerned, that we have got to comply with the ordinance, and they are going to compel us to eliminate the smoke emitted from the engines. They even threaten to sue us and say

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they will make us perform our duties. If there is no other way to do it, they tell us that we must use smokeless coal. I have lived in Minneapolis many years. The commercial clubs of that city will get together, get the business men together, and they even go so far, gentlemen, as to say and to intimate if you do not do so and so we will ship our goods by another railroad. What do you call that but boycotting? So I say what you say here to-day, whatever evidence you can give us on this subject, will assist us very greatly.

MR. MANCHESTER: I think we might perhaps live under some of the laws that are being enacted if we were given an opportunity to have them interpreted by the Supreme Court of the United States as to the " reasonableness " or " unreasonableness " of these laws, especially the ordinances against smoke; but I do not know that that is our only hope and salvation in the future. I have been hoping that the city authorities of some of our cities that are making us so much trouble, would jump on to their fire engine departments and arrest a few of the engineers of the fire engines as they are going to a fire. These engines create as much smoke in the city streets as do the locomotives on the railroads, which are usually in the less thickly settled sections. I have not seen any efforts made to mitigate the smoke nuisance in connection with city fire engines. They should apply the remedy at home and stop the fire-engine smoke.

THE PRESIDENT: Is there any one else who desires to discuss this subject? If not, I will ask Mr. Pratt to close the subject.

MR. PRATT: Some of the remarks which have been made remind me of the story of a man who was in his office one morning when a small boy came in all out of breath, running up to him and said, " Mr. S-m-i-t-h, your mother-in-law is dead." Mr. Smith said, " Don't make me laugh, I have a cracked lip." I notice that Mr. Manchester, Mr. Bentley and Mr. Fogg and some of the Chicago people, can not help covering their cracked lips a little when Minneapolis is shown to be active in this matter, and some of the New England States are getting busy.

Mention was made by one member of the use of the air blower, and I judge that is merely to induce a draught. There

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seems to be no reason in the minds of the committee why an air blower for inducing draught would be any better than a steam blower, nor quite as good.

Mr. Bentley has described our smoke washer, with which we are still experimenting, but I might add that in order to reduce the concentration of the sulphuric acid in the water used to wash the smoke, it takes about a half a million gallons of water a day, which at 7 cents a thousand gallons represents about $35 a day for water.

I do not know whether Mr. DeVoy is going to try to saddle this Ringelmann chart on every committee that makes a report. This is the second committee he has put it on, but this committee does not have much to do with the locomotive in any other period than that during which the locomotive is being fired-up. However, some of the discussion was a little wide of the report. I would like to say a word or two in that respect. The ordinances of several of the cities contain the words "dense smoke," which the railroad men generally call black smoke, and which is interpreted as "smoke through which objects are not readily discernible." A large locomotive generally develops 1,500 H. P. and, perhaps, has a stack 22 to 24 inches in diameter. While the velocity of the gases and smoke is greater than a chimney or stationary stack would be, there seems to be a good deal of feeling that the density of the smoke from that small diameter of stack would be greater, especially when mixing that smoke with steam or condensed steam, which is a combination not more readily penetrated by the vision than it would be from a chimney 10 or 12 feet in diameter.

With regard to the use of the Ringelmann chart, and its use in viewing moving trains — it is practically impossible for an observer, unless he is on the train, which they seldom are, to see a locomotive stack at the same angle. They see an engine and a train approaching, when, no matter which direction the wind is in, they get an oblique angle through the trailing smoke, and then they later see the locomotive receding and get about the same angle, whereas we all know if you see a stack approaching and look through the smoke, it looks very much more condensed than

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it does when you stand at one side and see a train moving at right angles to you.

The replies which the committee received indicated that where wood was rather scarce the use of old ties and especially scrap car wood was the general practice. It seems to me that some of the rules that Mr. Smith has mentioned as having been embodied in recent laws in Massachusetts have some features of advantage over the laws in other cities, and if there is a tendency to be reasonable, and give the railroads a chance to meet and apply such improved devices as may be developed, it seems to me that a law of that kind should be more generally promulgated when these matters are up in different cities.

THE PRESIDENT: We will now take up the next subject, the report of the Committee on Best Construction of Locomotive Frames, of which Mr. H. T. Bentley is chairman.

Mr. Bentley presented a report, as follows:

REPORT OF COMMITTEE ON BEST CONSTRUCTION OF LOCOMOTIVE FRAMES.

To the Members:

Your committee, called upon to make a report on Locomotive Frame Construction, has given the subject very earnest consideration, and in submitting our recommendations wish to thank the members who responded so fully to the numerous questions asked, and whose replies furnished valuable data for the committee to work from.

Mr. Lawford H. Fry, a member of the committee, was unable to meet with us, on account of living in Paris, but sent information showing the practice and experiences of various foreign railroads, which throws considerable light on the problem.

At the convention in 1904 this subject was very ably handled by a strong committee, and in reading over the reports we find we are traveling over much the same road as they did, and notwithstanding the great increase in size of locomotives, the commitee's recommendations still hold good and the frames still break.

Cast steel, made to a rational specification, careful foundry manipulation, adequate and suitable annealing, was spoken of as one of the remedies for frame breakages at that time, and it still is the favorite material, if properly designed, made and annealed.

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The clip binder was then, and is now, more used than probably any other type, the bolt and thimble style having been discarded in modern practice, owing to stretch of bolts.

The specifications suggested by the Committee of Steel-casting Manufacturers, and submitted to the Association in 1904, are as follows:

Material:

Acid open-hearth steel..... .28 carbon. .05 phosphorus. .05 sulphur. .60 manganese.

Frames will be rejected that show:

Less than .20 or over .35 carbon.
Over .06 phosphorus.
Over .06 sulphur.
Over .70 manganese.

Tensile strength per square inch, not less than 55,000 pounds.

Elongation in 2 inches, not less than 15 per cent.

All frames to be annealed.

After seven years it would be interesting to learn from the members if these specifications are entirely satisfactory, or, if not, what changes should be made to make them so.

While the breakage of a frame is a serious handicap, especially during busy seasons, yet the work of repairing has been simplified so that it is now possible to weld them in place with Thermit, oil, etc., and what used to be a two weeks' job, when all wheels had to be removed and frame taken to blacksmith shop, can now be repaired in place by dropping one pair of wheels and using oil, etc., and engine returned to service in a few days.

Before going into details, we wish to submit the recommendations and conclusions arrived at by the committee.

CONCLUSIONS AND RECOMMENDATIONS.

1. That frame breakage is even more general and serious than we were at first led to believe, very few roads being free from this trouble.

The longer the wheel base of engine, ordinarily, in combination with a roadbed having comparatively short curves, and with frames poorly designed or of inferior metal, or engines not properly kept up, the greater the trouble will be with frames breaking. This latter factor may not be reflected until after the engine has been put in good condition, and then a frame may finally break as a result of the previous poor condition of the engine.

2. We believe that with frames properly designed, if made of a good quality of cast steel, thoroughly annealed, with suitable cross bracing and engines kept up in reasonably good shape, breakage will practically be overcome.

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3. That a cast-steel, one-piece frame, properly designed, of good material and thoroughly annealed, is better than a wrought-iron frame, because of the difficulty in welding up the large section in a perfectly satisfactory manner, and also because, in a casting, bosses, lugs, etc., can be added without the necessity of bolts and studs.

4. That a bar frame is better than a plate frame, this being the opinion of people who have used both; the plate frame causing about as much trouble with breakage in Europe as bar frames do in this country.

5. The strap binder appears to be the favorite form of tying frame jaws together, although the cast-steel box binder, with adjustable wedges, has a number of friends, on account of its simplicity and ease with which it can be handled. The toes at base of jaws should be of sufficient depth and size to give plenty of metal to anchor to, whichever binder is used.

6. Cases have been reported where frame breakage was directly traceable to expansion of boiler not being properly taken care of by the use of sliding shoes; these shoes, if too tightly fitted or cramped in bolting, or if not lubricated, may prove unsatisfactory.

Supporting boiler by means of vertical plates, if of sufficient strength, provides a satisfactory means of taking care of expansion without imposing undue strains upon the frames.

7. We would recommend to steel manufacturers the necessity of making a study of locomotive-frame casting, and the proper annealing of same, as a number of roads are using wrought iron, but would prefer steel if they could secure reliable castings.

8. As a general proposition, frame breakage does not ordinarily occur until engine has been in service two years or more, the older the engine the greater the trouble; we have come across cases, however, where they have broken earlier than this on account of flaws, poor welds, or other defects.

ABSTRACT OF REPLIES TO QUESTIONS.

The breakage of locomotive frames appears to be very general, from the nature of replies received, as twenty-four representative roads out of twenty-five stated that they were having trouble in this direction; one road, with only fifty-nine engines, reported no trouble; another says, having some trouble, but nothing serious, while a third replies that, with cast-steel frames, considerable difficulty is experienced.

The absence of frame breakage reported by the Trinity & Brazos Valley Railway Co., having fifty-nine engines, led us to write Mr. Seabrook, the superintendent of motive power, and ask if he could explain why he was having no trouble, and also to give us the maximum curvature on the road, and will quote part of his reply:

"We attribute our success in preventing frame breakage to roundhouse attention. The engines are entirely looked after by the roundhouse

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force. Engineers are not held responsible for the inspection of engines underneath. When an engine arrives at the roundhouse, the inspector makes a very thorough inspection, and every bolt that shows any indication of working is immediately removed, the holes reamed out and a new bolt applied. Whenever it is possible, our practice is to equip each bolt with two nuts. This engine inspector also looks after the setting of wedges and keying up the rods, reporting the work that is necessary to the roundhouse foreman, who assigns the men to make the repairs.

"The age of engines runs from four to twenty-five years; the worst curve on road is 9 degrees 30 minutes."

In trying to analyze the cause of frames breaking, had to look to the methods that were being adopted to prevent breakage, and found the difficulty was being solved in a number of ways.

The binder and bolt appear to be responsible (when not kept tight) for considerable trouble; some roads report that they watch this very closely.

Another road is applying new and heavier section to frames that are breaking.

Reinforcing frames and lengthening splices is reported as being helpful.

Where wedges are not kept properly in place there will be more liability to frame breakages than where they are kept snug.

Splices working will cause strains to be thrown on other parts of frame, and probably cause breakages.

Extending the short top-splice back over the front-pedestal jaw has relieved some roads of trouble.

The adoption of the Walschaerts, or other outside gear, has probably done more to overcome trouble than anything else, on account of allowing additional bracing and stronger frames.

Some roads have increased the thickness of metal in both rails of frames and have applied heavier cross braces.

One reply indicated that the movement of driving boxes so that top of box would strike the frame was a bad thing for the frame, and incidentally would think it a bad thing for the engine crew.

Revised valve setting, so as to reduce compression, is reported to be helpful.

It is stated that applying hammered-iron sections has also overcome the difficulty.

In trying to find how long a frame might run before breakage, we received a number of replies to our question: "Have you any data as to age of frame at time of breakage," and found that few breakages occurred in less than two years from date engine was built, but after that the breakages became more frequent as age increased; cast-steel frames appear to be more unreliable than forged frames, some of the latter running from four to eight years before giving trouble.

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On some roads the change of valve gear from inside to outside, when accompanied by suitable cross bracing, has apparently overcome the difficulty, but in other cases it has been aggravated. It is our judgment that the larger and heavier the power, especially on crooked roads, the more liability there is to breakage.

As stated elsewhere, power that is kept up in absolutely first-class condition gives very much less trouble than where poorly maintained.

We were anxious to find out if any particular type or class of engine was causing more trouble than others, but from the replies received would be led to believe that all of the heavier power is more liable to breakage than the lighter engines, which would seem to indicate that the strength of frame has not increased in the same ratio as the power of the engine.

The Atlantic, Pacific, Mogul and Consolidation types seem to be giving lots of trouble on the different roads, and engines with inside valve gear appear to be more troublesome than with outside gear; this being probably due to their age and the larger number in service.

Cast steel and wrought iron are about equally used for frames, the former breaking due to poor castings, defects, shrinkages, etc., while the greatest difficulty with the latter is in getting sound welds.

To show the extent that frame breakages occur: one road in the United States had thirty-nine per cent of the total number of engines passing through the shops with frames broken, so they had to be welded — those, of course, being bar frames — whereas one English road with 1,545 engines, having slab frames, had over ten per cent of this number broken; but it was stated that frames could now be welded with oxy-acetylene in two or three days, whereas before it used to take them several months to make repairs.

It is stated on excellent authority that cast steel does not have as great life as wrought iron in locomotive frames. On one road the breakages were tabulated, and show that of a certain number of engines the life of the wrought-iron frame averaged 5.9 years, as compared with 5.5 years for cast steel, and that, on account of the great difficulty in getting homogeneous metal, uniformly annealed, wrought iron was preferred.

A large number of breaks occur from checks started in key ways, and it is suggested that proper fillets be made instead of leaving sharp corners.

Switch engines appear to be particularly free from trouble account of frames breaking, and we can only attribute this to the fact that frames may be heavier in proportion to the work they have to perform. We only had one reply stating that switch engines were in some cases giving trouble, and this was from a switching association.

Frame splices, as a general proposition, give lots of trouble, account of working, and several roads are now using a front-frame section which is welded on to the center of front jaw after the old part with splice has been cut off.

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One of the members, replying to the question, "Do you have more frames break with inside than with outside valve gear?" was fortunately able to give us some very interesting data on a large number of Consolidation locomotives, all built about the same time; of 228 with inside or Stephenson gear, 16 per cent gave trouble in one year (November, 1909, to November, 1910), whereas, with the Walschaert gear, of 172 passing through shops in same period, 18 per cent of them had to have frames welded, and it is probable that the design was responsible for this condition, as we understand, since then, the sections have been increased beyond the amount that is generally recommended by the locomotive builders.

We find that a number of roads are using vanadium-steel frames experimentally, but on account of the short time they have been in service it is not possible to state positively results obtained. One road reports a vanadium-steel frame broken after being in service eighteen months, and another in four months, while another states that two vanadium-steel frames broke in four months.

Where power is kept up in absolutely first-class condition and proper care is exercised in regard to frame bracing — pedestal binders or caps kept up, frame bolts and cylinder keys a proper fit, and by giving attention to driving-box shoes, wedges and brasses, and machinery in general, so as to avoid excessive pounds — there will be less liability to trouble with frame breakages.

On account of more engines with inside than with outside valve gears, and because of their greater age, it is only fair to assume that the breakage would be greater on the engines equipped with the Stephenson gear.

The question of cross bracing has been given considerable thought by your committee, and it was found that it was possible, perhaps, to have the frame so rigidly braced that trouble would occur, but that where a bracing was used that permitted a small amount of flexibility, it was better for the engine, as a whole, and the frames in particular.

It is recommended in cross bracing, that ties be fastened full length of pedestal jaw, vertically on rear pedestal, of each driving wheel, or as close an equivalent to this design as governing conditions will permit.

The thickness of bosses on cast-steel cross-tie braces are to be not less than 1½, preferably 2 times, diameter of bolt used in fastening.

All bolts, where possible, to have heads next to castings, to insure full bearing on bolt.

$$\text{Diameter of bolt at thread} = \text{nearest } \tfrac{1}{8}\text{-inch to } \frac{\text{Width of Frame.}}{4}$$

Where size of bolt comes in even sixteenths, the smaller diameter will be used.

Body of bolt to be 1-16 inch larger.

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As outside gears, with inside cross bracing, have been in use a comparatively short time, it is a difficult matter to say just what effect the cross bracing has had on frame breakage, but replies received in answer to our question No. 12 would seem to indicate that it is beneficial, and your committee believe it advisable, but are not yet prepared to say what design is best suited for all classes of power.

The four-cylinder, balanced locomotive, we believe, will be less liable to frame breakage, because of more uniform turning movement than a two-cylinder engine, but have not been able to get sufficient data to confirm this theory. The fact that all these engines are comparatively new makes it difficult to get much information about them.

At one time is was thought advisable to use a built-up frame for convenience in handling and making repairs in shops, it often being possible to take out a section (by removing a pair of wheels), weld it up, and return to place in a comparatively short time, but the great difficulty experienced in keeping splices tight, and the fact that it is possible to make almost any welds with frame in place, has brought about a decided change in ideas and practice.

It is our recommendation that a one-piece frame be used on all engines with piston valves, preferably with cast-steel filling between cylinders and bumpers, but on slide-valve engines it is usually necessary to resort to a two-piece frame, because of lack of strength at cylinders. For engines having trailing trucks, a slab, spliced to main frame at rear of back drivers, is generally used, and apparently with satisfactory results.

The question of quickly and adequately draining cylinders, so as to overcome undue strains on frames and other parts of machinery, does not appear to have had the consideration it deserves, and we would suggest to locomotive designers and builders that this matter be carefully looked into, particularly on piston-valve engines.

The opening of cylinder cocks by hostlers and engineers, and leaving them open until cylinders are properly heated, should be insisted upon.

With cast steel, a design can often be used that would be impossible in wrought iron. Some of the trouble experienced with cast-steel frames has been due to the attempt to make them exactly the same as if of wrought iron, instead of taking advantage of the greater possibilities of designing and making a satisfactory frame where cast steel is used.

We have endeavored to get some comparative costs of cast-steel and wrought-iron frames, but find it very difficult to do so. Some designs of frames, such as those having ribs of different thicknesses, or pedestal fits of increased width, would be almost impossible to make of wrought iron. Very heavy frames over 5 inches in width are extremely difficult to make satisfactorily of hammered iron, and for these reasons cast steel appears to be the only suitable material.

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Herewith comparison of specifications suggested on page 406, in the 1904 Proceedings, with those issued by the American Society for Testing Material:

1904.	American Society for Testing Materials.
Tensile strength, 55,000 min.....	60,000 min.
Elongation in 2 inches, 15 per cent..	22 per cent min.
Reduction in area, not specified.....	30 per cent min.
All frames to be annealed.....	All steel casting to be annealed, unless otherwise specified.
Bending test, none specified.....	A piece 1 by 1½ inches, bent cold around a bar 1-inch diameter to 120 degrees.
Size of test piece, none specified....	Specifically mentioned.
Test coupon, none specified.....	To be attached to each frame for test purposes.

Would suggest that, wherever possible, the specifications recommended by the American Society for Testing Materials be used, as a casting better suited to the requirements will be furnished.

We believe, however, that as an additional safeguard, it would be better to specify how frame castings should be annealed, and would recommend the following:

Steel-frame castings to be annealed must be heated uniformly to 850° C. (1,560° F.).

The heat must be applied slowly, so that all castings in all parts of the furnace are approximately the same temperature. As soon as the castings have reached the required temperature the furnace may be opened.

It has been the observation of a prominent superintendent of motive power that on road engines going ahead, practically all of the time, the right frame breaks more frequently on the right-lead engine, and on left-lead engine the left frame is more susceptible to breakage.

RULES FOR PROPORTIONING LOCOMOTIVE FRAMES.

A careful investigation of this matter shows that the stresses locomotive frames are subjected to are very complex, and that it is impossible to fully analyze them in an entirely satisfactory manner. The methods of proportioning, therefore, consist in using a low-fiber stress, derived from the known forces, which gives relatively higher factors of safety than are customary in the design of simpler and more easily calculated structures.

If the stresses in locomotive frames were produced only by the internal force of the engine itself, for example, as in the case of a sta-

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tionary engine, without reference to movement on the track, the problem would be a comparatively simple one. It is altogether probable, then, that the fiber stress of the frames under these conditions could be so accurately predetermined that no breakages would occur, if at all reasonable skill and forethought were exercised in their design.

This simple proposition for the stationary engine is complicated for the locomotive by the conditions under which it is operated. It has to run on all sorts and conditions of tracks, involving frequently great variations in horizontal and vertical alignment, excessive curvature, irregularities due to frogs, switches, etc. The stresses are influenced very materially by the speed at which the locomotive may run, both on straight and curved portions, involving vertical and lateral movements, the first usually due to irregularities of the track and the second to the centrifugal forces in rounding curves or to the swaying and lurching of the engine.

Because of the complex nature of the stresses, it is therefore impossible to satisfactorily account for all of them, and it is necessary to make the factor of safety, derived from the known stresses, correspondingly high in order to take care of the unknown stresses.

In building locomotives, it is customary to proportion frames in terms of the cylinder thrust; that is, the area of one cylinder in square inches multiplied by the boiler pressure. The resulting figure is taken for the basis, and this divided by certain constants for different portions of the frame produces frame sections proportional to the size and power of the locomotive.

Because of the simplicity and the ease with which proportions like these can be obtained, and on account of the extremely large unknown stress which can not be satisfactorily accounted for, the difference caused by the center of cylinders and the centers of frames are not usually considered. Assuming cylinder and frame centers of 86 and 46 inches, respectively, then these figures would be increased 60 per cent by taking into account the increased moments derived from the local dimensions given, but the increase is disregarded because it is nearly proportional in all engines and taken care of in the low constants.

The following approximate rules will produce sections for bar frames, either in wrought iron or cast steel, suitable for modern locomotives:

$$A=\frac{.T}{2{,}500 \text{ to } 2{,}700} \quad B=\frac{T}{3{,}000 \text{ to } 3{,}200} \quad C=\frac{T}{4{,}300 \text{ to } 4{,}500} \quad D=\frac{T}{1{,}600 \text{ to } 1{,}800}$$

T=Piston thrust (area of cylinder multiplied by boiler pressure).

A=Square inches of sectional area of frame, top of pedestals.

B=Square inches of sectional area of frame, top rail between pedestals.

C=Square inches of sectional area of frame, lower rail between pedestals.

D=Square inches of sectional area of frame, integral single rail at back cylinder-keying lug.

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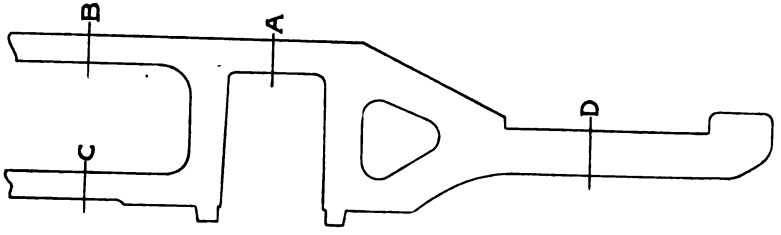


FIG. 1.

The width of frames is usually made in proportion to the weight and power of the engine. Frames of 6 inches are not uncommonly used for very heavy engines.

Most of the important bolts in a frame are vertical. Therefore it is often advisable to increase the width rather than make up the section entirely in depth, because the section is not cut away so much when large bolts are used, and for that reason, where 1⅜ or 1½ inch bolts are used, frames of greater width can be more economically employed than the narrower sections.

The above rules produce frames of slightly larger section than were customary a few years ago. It is interesting to note that a railroad which has been troubled with excessive frame breakage in older engines of light frame sections, have in recent years gone to sections almost equal to those given by the above rules, and in some cases have exceeded the weight and section produced by such rules.

It is also significant that, irrespective of transverse bracing or any refined methods of construction, there is a minimum amount of metal which can be safely used in the sections of locomotive frames that can not be reduced without incurring the risk of breakages sooner or later, when constructed of materials ordinarily available for this purpose.

Frame breakages do not usually occur for some time after the locomotives are placed in service, and in a general way it may be stated that many breakages do not occur until the engines have been in service for at least two years. Probably three or four years is the time when the greater number of fractures commence to occur, and from that time on in increasing numbers.

The above is only true in cases where there are no pronounced local defects, such as poor welds, shrinkage, or porous places in steel castings. Where local defects exist, the breakages are apt to occur in a very much shorter period of time, and a number of instances could be given showing that such fractures occur in from three to six months or even shorter time of service.

PLATE FRAMES.

A direct comparison can not be made between similar construction in service here and abroad, because plate frames are used almost entirely

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in Europe; therefore, when frame construction in the United States is compared with European frame construction it must necessarily take the form of judging the relative merits of the plate and bar frame construction.

A more or less vague impression appears to exist in this country that plate frames are freer from breakage than bar frames; and that although plate-frame construction is not suitable for American engines for various reasons, provided satisfactory designs for heavy locomotives could be made, that foreign railways are not troubled by frame breakages to the extent that we are accustomed to in this country.

Plate frames are more readily repaired than bar construction, with the possible exception of thermit welds, because a plate on one or both sides can be bolted or riveted which will usually satisfactorily reinforce the broken section. On account of their relatively thin sections, plate frames in some instances are also repaired by means of oxy-acetylene blow-pipe welds.

Because of the greater weight and power of American engines, it does not appear practicable to make a satisfactory design of plate frame which will provide the necessary bearing surface for driving boxes. This bearing surface is obtained by fitting and riveting on cast-steel horn blocks or pedestals, in which the number of rivets is such as to reduce the bearing pressure on the rivets to safe limits so there will be but little probability of their working loose; the idea being, that while their use is satisfactory for lighter engines, yet for the greater piston thrusts required on American engines it would be difficult to make a design in which the various parts could be riveted onto the plates in such a secure manner that the annoyance from loose bolts and rivets would not be much greater than with the present bar-frame construction.

The general tendency in the design of railroad rolling-stock is toward simplicity and the elimination of bolted parts, making or casting pieces together and working away as much as possible from built-up construction. From this point of view there does not seem to be much to be gained in the plate-frame construction, although such frames are made from one piece extending from the front to the rear of the engine, yet the pedestal horn blocks, spring fastenings and a number of other attachments are either bolted or riveted on.

Compared with the bar frame, which is used exclusively in the United States at present, plate frames are essentially a built-up construction, and in the erecting of an engine using such frames the alignment is much more difficult, involving more care and time, so that the erection of an engine is a longer process than when bar frames are used. This and other causes render plate-frame construction undesirable, in our opinion, as a possible substitute for bar frames.

Furthermore, it is a fact that the one-piece, integral-bar frame construction, when made of suitable material, is as free, if not freer, from defects or breakages than plate frames.

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From personal observation of a great many locomotives in the principal European countries and from reports obtained from railroad men abroad, the facts seem to be that plate frames often break, especially on the older classes of engines, and that unless made exceptionally heavy above the pedestal they may be expected to show partial or complete fractures after a certain period of service.

One English railroad reports that the frequency of broken plate frames may be judged by the fact that three hundred fractures have been repaired within the last two years. Taking into consideration the number of locomotives in use on that road, the average is almost exactly ten per cent of breakages per year.

One method of computing the maximum stress in plate frames is by supposing that the engine is being wheeled and that it is lifted by cranes from each end with the pedestal binders removed. The weakest part, therefore, is immediately over the middle pedestals. The frames are treated as a beam supported at each end and the load distributed. The resistance of doubtful sections is computed and the depth of plate increased until a factor of safety of between three and four is obtained.

Another method is to take the greatest piston thrust and proportion the frame so that the greatest fiber stress resulting does not exceed 1,000 kg. per square centimeter (14,220 pounds per square inch). In calculating this stress, the leverage caused by the distance of center of cylinder from center of axle bearing on the opposite side, the distance of bearings on main axle, as well as the leverage caused by the gap itself, must be considered.

One of the disadvantages of plate frames is that they can not easily be made as accurate nor can the alignment of the working parts be so easily accomplished as with bar frames, where all fitting surfaces are machined. The access to parts under the engine is not so good with plate as with bar frames.

It may be interesting to give extracts from an article written by Mr. I. Valenziâni, of the Italian State Railways, published in *l'Ingegneria Ferroviaria,* for November 1, 1910, which has a bearing on the subject. He says:

"Many European railways have purchased American locomotives, and while some details have been found unsuitable for European practice, it is none the less true that in other respects the American locomotives have given excellent results. Among the details which were largely appreciated in Europe must be included the bar frames, which have two great advantages over the plate frames; namely, the very much greater ease of examination and adjustment of parts lying between the frames, and the greater ease and rapidity with which the various parts can be attached to the frames during the construction of the locomotives. The advantage derived from the greater accessibility becomes still more evident when it is remembered that one of the great objections to the use

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of four cylinders has been the inaccessibility of the inside machinery. Considerable efforts have been made by the American designers of late years to reduce the difficulties and breakages. The excellent results given by the bar frames on the twenty locomotives purchased by the Italian State Railways from the Baldwin Locomotive Works indicate the success attained in this direction. Very good results have also been obtained by Maffei with bar-frame locomotives for various European railways. Maffei prefers wrought-iron bar frames, forged and welded, while Krupp has cut bar frames for the Baden State Railways from a single rolled plate of sufficient thickness. In addition to the facility of inspection of the machinery offered by bar frames, they have the advantage of rendering the washout plugs and the fire box stay bolts more easily accessible.

"In Europe bar frames are rather more expensive than plate frames to construct, and an extension of their use is attributable rather to this than to any technical reason."

NOTE.— This is probably due to the fact that the manufacturers are better equipped for manufacturing plate than the bar frame.

COMMITTEE.

As an interesting addition to the data contained in this paper, we herewith submit extracts from a report that was made by a representative of a locomotive company, who had been specially detailed to look into the subject of frame failure, but as a committee we do not agree with all his deductions.

"The number of frame failures which occur in the operation of locomotives in service is the cause of very serious delays, and represents at least twenty per cent of the expenditures necessary to keep an engine in service.

"On one division of a large road, having 705 engines, the average yearly number is 270 failures. On the other road, in five years, they repaired 786 frames on 197 engines. When the fact that each failure, which is serious enough to require taking down the frame, causes the loss of service of the engine from six to ten days, and an expenditure of $150 to $200, the subject becomes one of first importance."

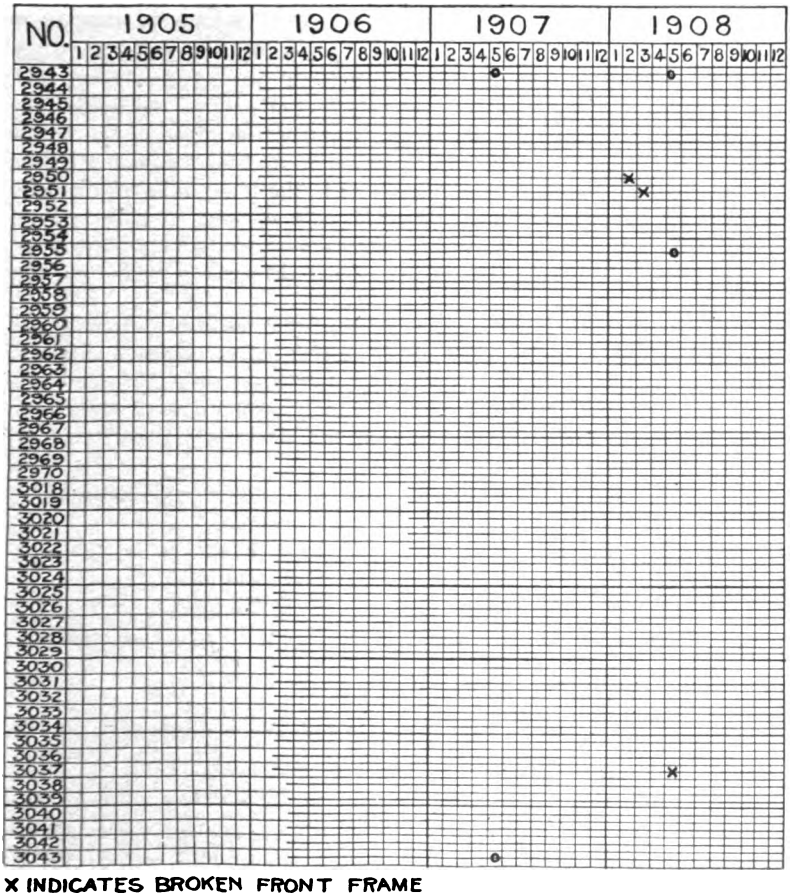
FRAME BRACING.

"A comparison of the types of locomotives in service, which were built prior to the past three or four years, shows that the bracing of the frames has not been carried out as we now believe to be necessary for good service.

"In an effort to overcome the number of failures, the sections of frames have been made heavier and splices increased in section and bolting power, but with several exceptions, the bracing of frames seems to have received less attention than it deserves. Experience shows that many engines with increased frame sections fail almost as much as they did with the lighter frames.

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PENNSYLVANIA RAILROAD
LINES EAST AND WEST OF PITTSBURGH
LOCOMOTIVES
RECORD OF FRAME FAILURES
CLASS H6B
ALTOONA PA



X INDICATES BROKEN FRONT FRAME
O " " MAIN "

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"The first conclusion is that a good design of bracing is more important than heavy frame sections. The stresses to which frames are subject can not be calculated, because the conditions of service, together with the load and direction of the forces acting, are constantly changing. Another factor is the condition in which the engine is maintained, as shown by several of the detail reports by roads having engines of exactly the same design on different divisions, some of which give little or no trouble, while other divisions report trouble constantly.

"An investigation carried out on one road several years ago proved that the frame at first pedestal vibrated 1-16 of an inch, both vertically and horizontally, and that in rounding a curve the bottom of the frame was deflected more than the top, which is the natural conclusion when we consider that the frames are usually braced only to the guide yoke, and knees at the top rail, and a light wrought-iron brace at the bottom rail. It is this twisting action on the frame which causes so many failures in the front leg of the first pedestal, and in the lower rails of the splice connections in consolidation engines, where the distance from the cylinder saddle to the pedestal is short. It seems to make no difference how heavy the frame rails are made, because if no other changes are made the frame will break just the same."

A very simple but effective chart for keeping record of frame breakage and length of time engines are in service before breakage occurs, is furnished by the Pennsylvania Railway, and is submitted herewith; on account of considerable frame trouble experienced, we were able to get very interesting and complete data from the Mechanical Department officials of this road.

H. T. BENTLEY, Chairman,
F. J. COLE,
L. H. FRY,
G. S. EDMONDS,
E. D. BRONNER,
Committee.

CHICAGO, ILL.

THE PRESIDENT: You have heard the report read by the chairman of the committee. If there is no objection, it will be received and opened for discussion. I think every one of us is interested in this subject. It interests me, because we have had any number of broken frames, and I would like to get all the information I can with a view to overcoming the trouble. We would be glad to hear from any of the members. Mr. Curtis, can you give us any light on the frame question?

MR. CURTIS: I can not give you any light on how to construct

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frames to keep them from breaking, but I will mention that the L. & N. Railroad have 150 consolidated locomotives with the Stephenson link motion. These locomotives were not troubled with frame breakages, but we built some fifty or more locomotives, with the same frame. The locomotives are practically interchangeable, except that these last engines were equipped with the Walschart valve gear. We have been troubled a great deal by the breaking of the left frame near the front pedestal, in the case of those engines equipped with the Walschart valve gear. I have looked the engines over and can not see any reason for the breaking of the frame. It breaks in a very strong place, and everything seems to be in a good condition, and I know that the engines are well kept up. In fact, the engines equipped with the Walschart valve gear receive the same care as those equipped with the Stephenson link. Therefore, I attribute the trouble to the Walschart valve gear. As to why it should cause this breakage of frames, I can not give any reason.

I will also say that of the engines that have the Stephenson link, there were about 25 of them that had a very large plate bolted on the back of the cylinder and extended backward about four or five feet. We had a great deal of trouble with these frames breaking until we removed the plates — until we removed what made the frames stiff we had trouble. We manufactured these plate frames, they were alike in every engine, they would break occasionally when they got old, but would not break right at the plate as they did before.

The report of the committee has drawn attention to the matter of the use of a binder. In designing locomotive frames, we have always used at least 2.5 inches of a lip on the bottom of the inside to hold the binder up tight. I think it is important to hold the binder and the frames solidly together, and it is necessary to stop the breakage of frames. I have found in an engine that some one believed in the binding question to such an extent as to have the binding extend the whole length of the frame. If you took down one binding you would have to take them all down.

Of course, as long as we have locomotives we will have the breakage of frames, as they will wear out, but I believe with proper bracing and care, by keeping the engine up, by giving it

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proper attention in the roundhouse, we will save ourselves a great deal of the frame breakage.

MR. BENTLEY: I would like to say something in line with what Mr. Curtis has just said. It would not do for us all to have the same experiences, but if you will read the report you will find one road had a lot of Stephenson gear consolidated engines that were continually causing trouble on account of frame breakage. They duplicated these engines — they got an order for about 200 engines, of each class, one with the Stephenson gear and one with the Walschart gear, and the Walschart gear-engine frames did not break, but the Stephenson gear engines did break their frames. They were both built at the same time, and used in exactly the same kind of service. That seems to be different from the experience of Mr. Curtis.

We have had a number of engines on our road, not very heavy, ten-wheel freight engines, but have had a lot of trouble with the Stephenson link engines breaking their frames, and we had a number of Walschart valve-gear engines, same general type and same size frame, but with the addition of a cross-bracing between the frames, and since they have been in service we have not had a single case of frame breakage with that particular class of engine. They have been in service about six years, and would begin to show some difficulty, if difficulty were likely to be experienced.

I want to draw your attention to some information we got from across the water. Mr. Fry was very helpful in getting information for us. While it does not do us much good, it goes to show that the theory of some of our members that if we used plate frames our troubles would be entirely overcome is hardly correct, from the fact that most of the European roads used plate frames and report having trouble with them breaking, but since the introduction of oxy-acetyline welding they are able to repair the frames readily and get them into service quickly.

We have an extract in our report from an engineer of the Italian State Railways. He has tried the plate and the bar frames, and he states conclusively that the bar frame has some advantages over the plate frame, namely, that it is easier to manufacture, more convenient to erect, very much easier for

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inspection, and, generally speaking, the American standard bar frame is preferable from every standpoint.

I feel very strongly on the question of frame-breakage, and think where the committee has gone on record to say that a good deal of the trouble of frame-breakage is absolutely preventable, it should lead the steel manufacturers to get together and see if they can not do something to help out the situation. The use of cast steel for frames is very satisfactory, if we can get good steel castings, and get them properly annealed. On the subject of annealing, if you will turn to page eight of our report you will see that we have made a recommendation: "Would suggest that, wherever possible, the specifications recommended by the American Society for Testing Materials be used, as a casting better suited to the requirements will be furnished.

"We believe, however, that as an additional safeguard, it would be better to specify how frame castings should be annealed, and would recommend the following:

"Steel-frame castings to be annealed must be heated uniformily to 850 degrees C. (1,560 degrees F.).

"The heat must be applied slowly, so that all castings in all parts of the furnace are approximately the same temperature. As soon as the castings have reached the required temperature, the furnace may be opened."

Now, I do not know whether any steel castings manufacturers are here, but if so, I would like to ask the President to extend to them the privilege of the floor, so that they may give us some information as to how they can assist us in the making of better castings. One road advised us that they were using a forged-steel frame, heat-treated, which had been very satisfactory in overcoming frame-breakage, and if any gentlemen here have had any experience with forged-steel heat-treated frames, we would be very glad to hear from them.

THE PRESIDENT: The subject is still open. Mr. Ettinger, we would be glad to hear from you.

MR. R. L. ETTINGER (Southern Ry.): We haven't any forged-steel frames, plain forgings, heat-treated. We have a great many cast-steel frames on modern power which have been satisfactory. Probably as many as 200 of the heavy engines have

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cast-steel frames, with an alloy in them, and with these frames we have not had any breakage at all. Some of the older engines have had their frames broken, but we have not had any epidemic of broken frames on modern power of the design we now use.

MR. PRATT: How long have the 200 frames been in service?

MR. ETTINGER: About six years, the oldest of them. The first, I think, we got about six years ago.

WM. FORSYTH (*Railway Age Gazette*): Since the committee has come out definitely in favor of cast-steel frames, it seems to me that there ought to be a good specification for the casting, just as Mr. Bentley said. This specification of 1904 is for a low-strength steel; it is a steel whose chemistry and strength corresponds very closely with ordinary boiler steel. It is soft. The committee further recommends as preferable to this the specification of the American Society for Testing Materials, which has a strength 5,000 pounds greater. Now, that specification of the American Society for Testing Materials is one which applies to steel castings generally, it is not specially for locomotive frames, and I believe it would be a good idea if the Association would request the American Society for Testing Materials to investigate this subject and have a committee frame a special specification for cast-steel locomotive frames and present it to this Association. If it is in order, I will make that as a motion.

Mr. Seley seconded the motion.

THE PRESIDENT: It is moved and seconded that the committee request the American Society for Testing Materials to make up specifications for cast-steel locomotive frames. All in favor of the motion say "aye"; opposed "no." The motion is carried.

MR. R. D. SMITH: We have had trouble with steel-frame breakages on consolidation type engines, with narrow fire boxes, and have lately come to the conclusion that the trouble has been not so much in the vertical stresses as the horizontal stresses, due, perhaps, to the long overhang and the fact that the breakages all occurred through the bolt holes. It is usual, when we have such troubles, to add more material top and bottom, and we have increased the thickness as well. Just what the results of this will

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be we do not know, because we have just changed our patterns and ordered our first set of frames strengthened in this way, but it has been my thought that the failures were caused by horizontal stresses, due to the swinging as well as the vertical stresses due to the overhang in some of these frames.

I quite agree with Mr. Forsyth that we should have some specifications for steel for frames.

MR. CHRISTOPHER: Do I understand this committee is to be continued on this subject?

THE PRESIDENT: That will be for the Executive Committee to decide.

MR. CHRISTOPHER: It would appear that the question of the quality of the steel is the chief point. It occurred to me it would be a good idea for them to determine the radius at the pedestals and those points, in making their recommendations, as well as the quality.

MR. SELEY: Acting on the suggestion made by Mr. Smith, if I had some information, I might get some sympathy. I must say the most perplexing frame breakage which has occurred to us lately is in the forward pedestal on Pacific type engine — new engines, massive frames, massive toes, massive binders, everything put up in good shape. We have had a number of breakages starting from the radius, extending upward, a perfectly straight break, through to the inside of the jaw, through six or eight inches of solid metal. It is a perfectly clean break, and it seemed to me at first as though the maker had welded on the toe, but as far as we can determine, that is not the case. Why they should break, I can not figure out. If any other member has had similar experiences, I should like to know how he righted the matter.

MR. SMITH: I believe that a well-designed steel frame will not break, if the boxes, wedges and shoes are kept up. If more attention is given in the roundhouse to keeping up those features that go to hold our frames together, like the binders and bracing, we will not have so much trouble with them.

MR. B. P. FLORY (N. Y. O. & W. Ry.): We have had experiences the same as the other roads in the large number of frames which have broken. We have a lot of fifteen simple engines, and

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every one of these engines have broken either one or both of the frames on the top rail underneath the rocker box. We came to the conclusion that the cause of the frames breaking was the probability of their not being sufficiently braced. They did not have frame braces on the bottom rail at all, and we put one on there and since that time we have not had any of them break.

I was very glad to see the committee recommend the cast-steel one-piece frame. I note, however, on page seven, that the committee says, "but on slide-valve engines it is usually necessary to resort to a two-piece frame, because of lack of strength at cylinders." That has not been my experience, as for probably four or five years I have used the one-piece cast-steel frame in the slide-valve cylinders and have had practically no difficulty with it.

THE PRESIDENT: Mr. Pratt, may we hear from you?

MR. PRATT: Mr. Flory mentioned the point on page seven about which I intended to say a word, and it occurred to me to say that if there are any of the members who find it necessary to make a two-piece frame, that a vertical splice would give very much less trouble from breakage than a horizontal splice. The vertical splice bolts at that point give us a great deal of trouble, and I have heard others say the same.

THE PRESIDENT: Mr. Chambers, you had a lot of trouble years ago—can you tell us how you have overcome your troubles?

MR. CHAMBERS: I think you have the wrong man in mind.

THE PRESIDENT: We would like to hear from you.

MR. CHAMBERS: We have not had any trouble at all, which you would term serious, in frame breakages for a few years. We had a type of twelve-wheel locomotives, 105 tons, and it gave a great deal of trouble from frame breakages right over one box, but we designed a cast-steel section, cut off back and forward of the pedestal, and have had no trouble with the rest of the frame anywhere. Out of possibly 51 locomotives, we had 35 breakages on the right side, and only one on the left, so it was not necessary to put a cast-steel section on the left side.

We have ten heavy locomotives, equipped with the Walschart gear, which have been in service, I think, for about four years.

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We have not had any frame breakages in any of these engines, and I was a little surprised to hear Mr. Curtis say that in his opinion the Walschart gear had anything to do with the trouble. I think more than likely it is due to frame construction.

MR. ANGUS SINCLAIR: I would ask Mr. Chambers if the Walschart engines had the same bracings as the link-motion engines?

MR. CHAMBERS: Yes, they had better frame bracings than the link-motion engines. That is the natural conclusion. That might have had something to do with it.

MR. CURTIS: I ask Mr. Chambers if the engines were both framed on the right-hand side? I wish to call attention to my remarks to the engines with the Walschart gear, in which the frames were broken, that it was only the right-hand frame in these engines which were broken, and not the left.

MR. CHAMBERS: These were in all cases the right-hand lead.

MR. YOUNG: We had a great deal of trouble with the breaking of frames on the consolidation type of locomotives, the same size as the engines to which Mr. Chambers referred. They were equipped with the Stephenson gears. On the lines west I think there were about 325 engines, and the frame breakages ran up to over a thousand. We followed them in 1906 with the outside gear engine, identical in every respect, excepting the gear, frames the same section, but being cross-braced, the idea being to carry the cross-bracing back from the cylinders just as stiff as you could to the ash pan, and outside of manufacturers' defects and poor castings, I believe we have not had a broken frame which could be attributed to poor construction. I believe that the Walschart valve gear has solved half of the broken-frame trouble, because you can cross-brace frames, making a rigid structure back of the cylinders, and tie the two frames together, reducing the lateral vibration.

Mr. Pratt suggested the vertical splicing in preference to the horizontal splicing. We had so much trouble on the first consolidation engines that we made a number of experimental designs to increase the horizontal splice. That did not seem to do much good. The frames still broke; it simply carried the break a little

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further back. Most of the earlier breaks were right at the splice, ahead of the front driving box, and when we increased the weight of the splice, it went over back in the frame and broke over the front driving box, or between the front driving box and the intermediate wheel. We built a vertical splice ahead of the front drivers, using about twenty-four short bolts. We have about twenty of these engines running; they have been running about three years, and none of the frames have broken. Those are the engines which could not be cross-braced on account of the Stephenson gear. Our experiences with cross-bracing in the single bar frame makes the best construction to avoid the breaking of frames, and that is the practice we are following on our later designs of consolidation and Pacific type of engines.

MR. J. F. ENRIGHT (D. & R. G. R. R.): I had intended to make some remarks on this frame report, but from the fact that we are not experiencing the same trouble as some of the lines whose representatives have spoken on the subject, I was a little afraid that any statement I would make to that effect might not be credited. We are not experiencing a great deal of trouble with broken frames at this time, which is possibly due to the fact that our engines are in shops oftener for class repairs than is the case with engines operating on level roads. Our three and four engine trains make the operation severe on the train engine, onto which two and three heavy engines are at times coupled. Our experience has demonstrated the one-piece frame recommended by the committee is the best design for the piston-valve engine when a two-bar front section can not be provided for. We have a number of engines with the one-piece frame in passenger service with Walschart gear, and, with one exception, I do not recall a broken frame on these engines. The exception was a break at the wedge side of the main pedestal about midway between the binder and the top frame, and could not ordinarily be charged to frame design. The frames that break with us are mostly on our older engines — engines that have been in service for a number of years and when the wrought-iron frame exclusively prevailed. With the heavier steel frames we are using to-day on our slide-valve engines, with top and bottom bars, i. e., one over and one under cylinders, we experience little or no trouble, despite the

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heavy service incident to three and four engine trains. I think the report of the committee very ably covered the matter of frame construction. I am particularly interested in the mention made in the report of the roundhouse practice of Mr. Seabrook, of the T. & B. V. R. R. I believe that such practice will go a long way toward diminishing the number of broken frames. The clip binder is, in my opinion, the only binder that should be used.

THE PRESIDENT: Mr. Rumney, you have had trouble with your frames breaking, have you not?

MR. RUMNEY: Yes, we have had trouble and I have not heard of any one who has not, except the fortunate gentleman representing the Denver & Rio Grande Railroad, and the conditions of that road, of course, are somewhat unusual. We have tried to do everything that has been recommended by the Association from time to time, and have conferred with the builders of locomotives in making various designs, to strengthen and stiffen up the frames in every way desirable. Large fillets and single frames are used and additional braces applied as far as possible. There are some engines running that have not broken a frame in two years, and others of same type running, that have not broken over two or three frames on about thirty engines in four years; but the same type of frames on similar engines built at different periods, to same specifications, have broken, so that it is pretty hard to determine where we stand. We have some alloy frames that have run for four years without trouble, whereas failure has occurred with similar engines built at the same time with ordinary cast-steel frames, which places the alloy frames in a favorable light.

THE PRESIDENT: Mr. Hancock, will you give us the benefit of your experience?

MR. HANCOCK: My experience is about the same as our neighbor's here. We tried to figure out the cause of broken frames, but are at a loss to know how to prevent it. We have bracing back of the saddles. Where the frame passes over the cylinder's saddle, the bolt holes close to the saddle has reduced the section at that point, and a knuckle is formed that frequently leads to

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failure. At this point the section has been increased about an inch, which has remedied the trouble to quite an extent.

Many of the failures occur at the front pedestal. The repairs are made by plating on each side. This method of repairs appears to be satisfactory in many cases. We have a large number of engines which have been in use four or five years and have not broken their frames, while others of the same class which have been in use only a year have failed.

On some sections of the line the failures appear to be greater immediately back of the saddle, especially on the old engines, while the same engines on portions of line where the curvature is not excessive and speed slower, less failures are noticeable. The old power of the consolidated type with small wheels, on sections of the line where curvature is 8 to 10 degrees, fail frequently, while on other portions of the line, on comparatively straight track we have very little trouble.

MR. CHAMBERS: I would like to add a word for the benefit of the members — on those engines in which we had the frames break, the twelve-wheel type of engine, the frame broke just over the forward jaw. We had a splice just in front of the jaw. For a time we used a cast-steel section, using the same kind of splice, and since then, about a year ago, we went further ahead, just back of the cylinder and cut-off where the frame is a single bar and made the section cover that point. We have a one-piece frame, and it has been very successful, doing away with the trouble of splicing the top.

THE PRESIDENT: Mr. Manchester, can you suggest a remedy for these frame troubles?

MR. MANCHESTER: In our modern engines, in the engines built in the last three or four years, we do not have very many cases of broken frames, but in most cases where there has been a broken frame, and inspection of the break determined the cause, we found that there was some defect that indicated the cause of the break. The engines which we build at our Milwaukee shops we provide them with iron frames. We make these frames in our own shops. In the case of the engines purchased from the builders, they have generally been steel frames, and I do not see

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any difference between the serviceability of the frames built in our own shops and those built by the manufacturers.

A thought occurred to me when Mr. Curtis was referring to his troubles with the Walschart geared consolidated engines. We have 175 consolidation engines with 56-inch wheels. The first few years that these engines were in service they were kept entirely in a moderately slow speed, but very heavy service, the engines hauling from 3,000 to 5,000 ton trains. Later on, a condition developed due to the particular weight and length of these engines, and we had to transfer them to another district where the speeds were high. In the slower heavy service we had practically no broken frames, but when we turned the engines over to the fast service we had a great many broken frames. This is possibly due to the point raised by one of the speakers, due to the small wheel, that we can not entirely balance the engine according to rule, and I believe that that was one of the things that caused the trouble with these engines. The thought occurred to me that perhaps Mr. Curtis was not using his Walschart engines, which had had broken frames, in the same service that he was using the other engines.

THE PRESIDENT: We have had considerable trouble with frame breakages, both with Pacific type and consolidation engines. It seems to make very little difference whether the engines are running on a part of the road with a great many curves or on a part of the line with practically straight track. The breakages occur mainly in the top rails between the forward driver and the cylinder. To overcome this trouble, we have extended the top rail beyond the rear of the front pedestal far enough to apply a bolt back of the jaw, doing away with the cast-steel guide-yoke bracket, forging a knee on the top rail to take the place of the guide-yoke bracket. We have forty of our engines of this construction which have been in service twelve years on which we have no record of a broken frame. It is true these are light engines, but our plan seems to be working successfully on our latest class of heavy engine.

We commenced changing the Pacific type engine frames to this design about two and a half years ago, since which time we have had no breakages on these engines. I was in hopes this

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committee would be able to throw some additional light on this subject. I do not know whether the plan we are following will overcome all frame breakages or not, although so far it has been very effective.

We feel that the separable guide-yoke bracket, about 20 inches high, necessary to get the guide yoke up high enough, consisting of a loose cast-iron bracket bolted, which was not always tight, but was frequently loose, was largely responsible for our trouble. I simply make this statement for the benefit of the members.

Also, we feel that the method of attaching the back of the boiler to the frame is not as substantial as it should be, necessarily causing some of the failures.

MR. R. W. BELL (Illinois Central R. R.): About three years ago on the Illinois Central R. R. we had a great many frame breakages, and we started a systematic campaign to ascertain the way in which our engines were taken care of in the engine-houses. We found that our frames broke on the engines that were neglected, wedges that were down, wedges that were not kept in condition, brasses not taken care of, and we started a campaign of education of our engine-house forces, and after we introduced better methods of caring for the engines, our frame breakages were reduced to a minimum. I think the greatest causes of frame breakages are loose wedges and loose binders. It is true, that the design of the frame has something to do with it, but I think if the engine is kept up in a state of high efficiency, all the rods and boxes in proper order, it will be found that frame breakages will be greatly reduced. That is our experience. We have 1,449 engines, and since last July our frame breakages have been one per cent.

MR. D. J. REDDING (P. & L. E. R. R.): We have had about the same experience with broken frames as has been mentioned by other speakers, and believe that proper bracing has a great deal to do with preventing frame breakage. We had a lot of consolidation locomotives on which the frames broke in front of the front pedestal, and came to the conclusion that the main cause for the breakages was that these engines had insufficient bracing between the guide yoke and the boiler. This brace consisted of a thin sheet bolted to one side of a tee iron attached to the boiler,

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and after a few trips the bolts would be found loose at this connection. By putting in two plates at this point, thereby making it possible to bolt them solidly to the tee iron and applying a cast steel U-shaped section between the top and bottom frame rails back of the cylinders, we apparently stiffened up the frames sufficiently to overcome the effect of the thrust from the crosshead at the back end of the guides and eliminated the breakage of these frames, and it would seem to me that if anything could be added to the report of the committee, it would be some suggestions as to what had been found to be satisfactory bracing for frames. Some locomotives are turned out by the builders, which, so far as the frame-bracing is concerned, appear to have been sadly neglected, particularly in the matter of waist sheets between the frames and the boiler.

MR. GEORGE W. RINK (Cent. R. R. of N. J.): I believe the frame bracing is an important part of the locomotive. The style of boiler support bracing used on locomotives in recent years simply set on the top rail and the bolts pass through vertically. The bracing does not lip over the outside of the frame in order to take the shear off the bolts. It is only a question of a few months after the engine is placed in service when the bolts become loose and the frame in turn becomes loose. What is the use of applying frame-bracing to an engine if it does not stay tight. I have an idea that sufficient metal is not applied vertically at the bolt holes in the braces. Where you find braces with anywhere from three-quarters of an inch to one inch of metal through the bolt holes, the same should have at least an inch and a quarter or an inch and a half of metal, and the frame-bracing should extend from the top rail to the lower rail, so as to brace crosswise, in other words, use a brace in the shape of the letter X. I believe that would be far preferable than using a large flat brace lying on the top rail. We have found it necessary to apply to engines originally built with such a brace, an additional brace to the lower rail, and extending a sheet from the top frame casting to the lower additional bracing. That applies principally to the front furnace supports.

I believe the use of a sheet connecting the mud ring into the supporting casting is a good idea. As far as the thickness of the

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sheet is concerned, I believe the thinner the sheet used the better, as it provides greater flexibility.

My attention was called the other day to an eight-wheel engine that had the front jaws broken on top at both sides. This engine had a frame of about four by seven, and had underhung springs. The wedge required lining up and it was neglected as it was hard to get at on account of the spring, and I can attribute the cause of that breakage to the fact that the wedges were not properly lined up.

We have a large number of cast-steel frames in service, a number of frames made of .40 carbon steel, introduced on our latest switching engines, and as far as these switching engines go we have had no trouble. The particular engine Mr. Chambers referred to had a cross spring extending from one driver box to the other, and the frame was cut out on the inside a trifle on an angle, which weakened the frame at that point. We got out a new cast-steel section, and added two inches to the depth of the frame at that point, and have experienced no trouble with the new section.

THE PRESIDENT: We will ask Mr. Bentley to close the discussion on this report.

MR. BENTLEY: The President has asked for some information on this subject, and I would refer him to the third paragraph of our report, which says: "At the convention in 1904 this subject was very ably handled by a strong committee, and in reading over the reports we find that we are traveling over much the same road as they did, and notwithstanding the great increase in size of locomotives the committee's recommendations still hold good and the frames still break."

I agree with Mr. Bell, of the Illinois Central, and Mr. Scheffer, of the St. Louis Southwestern, who report having had no trouble, due to getting a better grade of steel.

It has been stated to me that the committee has done an injustice to the vanadium steel frames, in so far that we did not state how many frames were in service when we stated how many were broken, and to try to straighten that out I will give the result of the information I got at the time this report was compiled: One set, none broken; five sets, none broken; one set,

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none broken; three sets, one broken; one Mallet, four frames, none broken; three sets, none broken; two hundred and thirty sets, none broken.

I would not like to do injustice to anybody in connection with this report, and that is why I bring this matter up.

Mr. Chambers spoke of the one-piece frame eliminating the splice. I think that is the universal practice now. Everyone knows what troubles they have had with splices, and they have gone into the practice of making sections, and welding the section in the center of the front jaw, and I think it is a good thing to do — that is the practice we are following. But I could not understand Mr. Chambers saying that he did not have any frame trouble. I probably misunderstood him, because in the tabulation which the committee made in answer to the question "Are you having trouble with the breakage of engine frames?" he answered, "Yes." Of course, it may be that he is not having this trouble now, but was having it at the time he made his reply. I will not take any more time, but thank the members for their attention.

The meeting then adjourned.

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THURSDAY'S SESSION.

President Fuller called the meeting to order at 9:30 A.M.

THE PRESIDENT: Gentlemen, if you will kindly come to order we will proceed with the work of the meeting.

THE SECRETARY: Mr. President, I have received word that Mr. W. C. Hayes, of the Erie Railroad, has been selected by the Traveling Engineers' Association to represent that Association at this convention.

THE PRESIDENT: The first order of business is the paper on Main and Side Rods, Mr. W. F. Kiesel, Jr., being chairman of the committee.

Mr. Kiesel presented the report as follows:

REPORT OF THE COMMITTEE ON MAIN AND SIDE RODS.

To the Members:

The following is submitted as a progress report, coupled with the request that every member of the Association send the committee criticisms or suggestions for modifications before February 1, 1912. The data already furnished by the members form a very interesting study, for which reason it has been added in tabulated form as "Appendix A." You will note that the basic formulæ agree with each other closely, that in most cases the calculations are based on 336 revolutions per minute, but that there is some variation in the assumed amount of strain from piston pressure transmitted to side rods. As a basis for close calculations, Professor Gaetano Lanza's method of calculation is given in "Appendix B."

The first part of the subject assigned to your committee relates to kind of material in rods. From Appendix A it will be noted that there is very little difference in the steel for rods, and that open-hearth steel having an ultimate tensile strength of 80,000 pounds per square inch is used by all railroads. There is some variation in the chemistry. Special alloy and heat-treated steels have been considered and put in service, but, to date, information relating to such steels in rods is too meager to justify recommending their use.

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The second part of the subject relates to specifying formulæ for checking up sizes and designs of main and side rods.

1. Main Rods.— The rod bodies are subject to the following strains:

First: Tension and compression, due to piston pressure and inertia of reciprocating weights.

Second: Bending, caused by centrifugal force acting vertically.

Stresses from compression are always more than from tension.

Reciprocating parts are made as light as possible, and stresses due to inertia of reciprocating weights are usually less than those created by cylinder pressure. Furthermore, when drifting, the amount of retardation, due to vacuum and compression in the cylinder, will, to some extent, balance the inertia strains. If for passenger and high-speed freight locomotives the maximum piston pressure is less than the product of the reciprocating weights by four times the crank length in inches ($P < 4rW$) the latter value ($4rW$) should be used in place of maximum piston pressure. For slow freight and shifting engines, such substitution is not necessary.

From the above it will be noted that the calculations may be confined to a consideration of rod body as a strut, with load equal to the piston pressure, or its substitute, and as a beam subject to bending on account of whip action at high speeds.

2. Side Rods.— The rod bodies are subject, first, to tension or compression arising either from a part of the piston pressure transferred through main crank pin, or from a requirement for the rod to slide one or more of the driving wheels, and, second, to bending caused by centrifugal force acting vertically.

When all drivers are not of exactly the same diameter, and when the locomotive is passing over curves, the side rods must slide drivers. The limit of the force to slide drivers is governed by the coefficient of friction between wheels and rail. The commonly accepted coefficient of friction, when calculating tractive power, is .25, or less. For our purpose it should be taken somewhat higher, to be on the safe side. A number of builders and roads use the coefficient of .3, which fully meets the requirements.

For starting, we assume that each rod must be capable of sliding the *pairs* of drivers to which it imparts rotation, but when running at speed it must slide the drivers on one side only. Therefore, the value P in Professor Lanza's formula would be

$$P = \frac{WR}{r} \text{ for starting}$$

$$P = \frac{WR}{2r} \text{ for running at speed, in which}$$

W=Weight on pairs of drivers receiving rotation from the rod

R=Radius of wheel

r=Radius of crank.

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As stated at the beginning, most roads base calculations of rods on a speed of 336 revolutions per minute. This is high for some engines, such as Mallet compounds, and low for fast passenger engines, some of which now reach a greater speed, and the tendency is to achieve still greater speed. The use of 375 revolutions per minute, for fast freight engines and passenger engines, and 420 revolutions per minute for fast passenger engines, would be sufficiently high for ordinary locomotives. For Mallet compounds, and other very slow locomotives, a special figure may be taken.

3. Rods as Struts.— Main rods are almost invariably made taper, and the section, if fluted, may vary in thickness of flange, height of web, thickness of web, or a combination of two, or all three. The taper is never of such amount that the results are appreciably affected if calculations are based on the section at the center, the same as for rods having a uniform cross-section. Good practice indicates that this center area for all rods should not be less than maximum assumed end load divided by 10,000 pounds. Merriman's Rational Formula for columns (see Kent's Pocket Book) is

$$C = \frac{B}{1 - \frac{nB}{\pi^2 E} \frac{L^2}{r^2}}$$ in which

B=Unit load

C=Maximum compression unit stress

L=Length of column

r=Least radius of gyration

E=Coefficient of elasticity

n=1 for both ends, round

n=¼ for both ends, fixed or flat.

If we have a unit stress of 10,000 pounds per square inch, the value of length divided by least radius of gyration (L÷r) must not exceed eighty (80) for neutral axis vertical or parallel with side of rod, and not more than one hundred and sixty (160) for neutral axis horizontal. For these values the maximum compression unit stress is 12,710 pounds per square inch, or slightly within the assumed figure for maximum allowable stress of one-sixth of the ultimate tensile strength.

From Appendix A it may be seen that with few exceptions these values of (L÷r) are not exceeded, and that the rods which show higher values have sufficient excess area to make up for it.

With neutral axis vertical for rods having rectangular section $r = b \sqrt{12}$ ("b" being the depth of section). Substituting this in L÷r=80, we get L=23b. Therefore, if the length from center to center of pin is less than twenty-three (23) times the depth of a rectangular rod, the value L÷r is less than 80. Similarly with neutral axis horizontal $r = a \div \sqrt{12}$ (a" being width of rod) and the value L ÷ r is less than one hundred and sixty (160) when L is less than forty-six (46) times the width of section.

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4. Offset Rods.— A number of the rods given in Appendix A are offset, that is, the vertical center line of the bearings at the end do not lie in the same plane, or in the plane of the center line of rod body. The greatest offset given is $1\frac{13}{16}$ inches. This creates a bending strain and increases the stress in the rod body. The added stress from this source is equal to the product of the maximum end load and the offset, divided by the section modulus with axis vertical, and requires a correspondingly larger section modulus.

5. Side Rods with Knuckle Joints.— Rods for three and four coupled locomotives must be provided with knuckle joints. The knuckle joints are all necessarily flexible vertically, and some are flexible horizontally also. When the drivers on one side are not in perfect horizontal alignment, slight bending strains occur, in addition to the compression strains. To take these bending strains into consideration would complicate the formulæ.

The end pressures on the rods being based on driver weight and a coefficient of friction greater than that expected, the margin in this assumption is sufficient to compensate for the bending strains arising from the non-alignment of the drivers on the one hand, and the deflection of the rod due to centrifugal force, when running at high speed, on the other hand; therefore, both bending strains may be ignored for the purpose of simplifying the final checking formulæ. When running at speed the centrifugal force from the short rod connected to the extension of the long rod reduces the bending strains due to centrifugal force in the long rod. As the extension to the long rod is short, this effect may also be ignored as the possible reduction in weight of long rod would not be appreciable.

When the drivers, due to wear between hubs and boxes, etc., are not in vertical alignment, bending strains are induced. Knuckle joints are at times made flexible transversely, in addition to the vertical flexibility, for the purpose of eliminating the bending strains. For locomotives on which a large amount of side play is allowed to accumulate, this transverse flexibility is of great value, to avoid rod failures. When the knuckle joints are flexible in both directions, the value of $L \div r$, for the short rods, should be one hundred and ten (110), instead of one hundred and sixty (160), given in No. 3 (rods as struts).

6. Bending Strains Due to Whipping, at High Speed.— For main rods the point of maximum bending strain is always very close to six-tenths of the length from crosshead end. This statement is based on the examination of a large number of rod designs. The section at this point may, therefore, be taken as the governing section.

For side rods the point of maximum strain is at the center.

The formulæ for determining the stresses at these points may be found in Appendix B.

7. Simplification of Formulæ.— As accurate calculations are rather lengthy, and must necessarily be based on conditions representing extremes, simple formulæ giving values within a very small per cent of those obtained

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by the more accurate method are better adapted for the purpose and especially useful for checking.

The basis for bending strains at speed is centrifugal force (F).

If G represents the weight, considered in pounds and r represents the crank radius, in inches, then

Centrifugal force	=	2Gr	3Gr	4Gr	5Gr for
Number of revolutions per minute		265	325	375	420

A cubic inch of steel weighs closely .2833 pounds. Both main and side rods may be considered as having a uniform section, equivalent to the governing section and extending from pin to pin. This assumption is accurate for side rods, but for main rods gives stresses at high speeds, possibly one per cent higher than those found by the accurate method.

If A=Governing area of rod, in square inches
and L=Rod length, center to center of pins, in inches,
then G=.2833 AL
and Gr=.2833 ALr
For side rods the bending moment M=.125FL.

For main rods, the formula in Appendix "B" may be simplified in the form M=.064FL.

The formulæ for bending moment (M) for main rods and side rods, at the assumed speeds, are noted in the following tabulation:

Revolutions per minute	265	325	375	420
"M" for main rods..	$.036AL^2r$	$.055AL^2r$	$.073AL^2r$	$.091AL^2r$
"M" for side rods...	$.071AL^2r$	$.106AL^2r$	$.142AL^2r$	$.177AL^2r$

From the above, the stress due to whipping action may be found by means of the well-known formula, $M \div SM$=Stress, to which the stress due to end strains, assumed as maxima, must be added. The sum of these stresses should not exceed one-sixth of the ultimate tensile strength of the steel.

8. Rod Ends.— The common forms of rod ends are shown by diagrams in Appendix "A," and the areas of important sections have been determined and may be found in the tabulation. The past years of experience clearly show that the stress must be kept low.

9. Knuckle Pins.— Data in regard to knuckle pins have not been included as the rules governing pins for wheels and crosshead should also govern knuckle pins, and if the bearing surface of the knuckle pin is sufficiently large to avoid trouble, the shearing area will be excessive.

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CHECKING FORMULAE

ALL MEASURMENTS ARE GIVEN IN INCHES AND POUNDS

A = AREA OF SECTION CONSIDERED

a = WIDTH " " "

b = DEPTH " " "

C_1 = MAX. COMPRESSION UNIT STRESS FOR TRANSVERSE BENDING

C_2 = " " " " " VERTICAL "

c = $c_1 - c_2$ = COEFFICIENTS

d = CYLINDER DIAMETER

L = LENGTH OF ROD FROM CENTRE TO CENTRE OF PINS

M = BENDING MOMENT

P = MAX. COMPRESSION STRAIN ACTING AT END OF ROD

p = MAX. BOILER PRESSURE

Q = CYLINDER PRESSURE = $0.7854\ d^2\ p$

R = RADIUS OF DRIVING WHEELS

r = " " CRANK

RG = RADIUS OF GYRATION OF SECTION - AXIS HORIZONTAL

rg = " " " " " - " VERTICAL

S = STRESS, - AND WHERE USED IN FORMULAE MUST NOT EXCEED ONE SIXTH OF ULTIMATE STRENGTH OF THE STEEL

s = AMOUNT OF HORIZONTAL OFFSET IN ROD

SM = SECTION MODULUS OF SECTION CONSIDERED - AXIS HORIZONTAL

sm = " " " " " - " VERTICAL

W = WEIGHT ON PAIRS OF DRIVERS ACTUATED THROUGH ROD CONSIDERED

MAIN ROD AREA MUST NOT BE LESS THAN P + 10 000 LBS.

FOR MAIN RODS $P = Q$

FOR SIDE RODS $P = \frac{0.3\ WR}{r}$

TO DETERMINE C_1 AND C_2, CALCULATIONS SHOULD BE BASED ON A SECTION HALF WAY BETWEEN ROD PINS

FOR TRANSVERSE BENDING IN RODS HAVING KNUCKLE PINS FLEXIBLE TRANSVERSELY

$$C_1 = \frac{\frac{P}{A}}{1 - \frac{P L^2}{675\,000\,000\ A\ rg^2}}$$

FOR ALL OTHER RODS

$$C_1 = \frac{\frac{P}{A}}{1 - \frac{P L^2}{1\,200\,000\,000\ A\ rg^2}}$$

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FOR VERTICAL BENDING IN ALL RODS

$$C_2 = \frac{\frac{P}{A}}{1 - \frac{PL^2}{300\,000\,000\ A\ Rg^2}}$$

VALUES FOR C_1 AND C_2 CAN ALSO BE TAKEN FROM TABLES IN "KENT'S POCKET BOOK" UNDER HEADING "MERRIMAN'S RATIONAL FORMULA FOR COLUMNS".

FIRST—

FOR RODS WITHOUT OFFSET THE LARGER VALUE OF C_1 AND C_2 SHOULD BE TAKEN EQUAL TO S.

FOR RODS WITH OFFSET THE LARGER VALUE OF $C_1 + \frac{P_s}{S_m}$ AND C_2 SHOULD BE TAKEN EQUAL TO S.

SECOND—

$$S = c\,\frac{AL^2r}{S_M} + c_1 P\left(\frac{1}{A} + \frac{s}{S_m}\right)$$

THE CALCULATIONS SHOULD BE BASED ON A SECTION LOCATED AT A DISTANCE 0.6 L FROM CROSSHEAD PIN FOR MAIN RODS, AND HALF WAY BETWEEN PINS FOR SIDE RODS.

VALUES OF c AND c_1

REV. PER MIN.		265	325	375	420
MAIN ROD	c =	0.036	0.055	0.073	0.091
	c_1 =	0.500	0.500	0.400	0.300
SIDE ROD	c =	0.071	0.106	0.142	0.177
	c_1 =	0.500	0.500	0.500	0.500

THE COEFFICIENTS SELECTED SHOULD CORRESPOND WITH THE HIGHEST NUMBER OF REVOLUTIONS PER MINUTE WHICH THE LOCOMOTIVE CAN MAKE.

IF THIS CAN NOT BE DETERMINED, USE

420 R.P.M. FOR HIGH SPEED PASSENGER LOCOMOTIVES
375 " " PASSENGER AND HIGH SPEED FREIGH LOCOMOTIVES
325 " " ALL OTHER LOCOMOTIVES

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VERY SIMPLE RULES FOR RODS, WITHOUT OFFSET, AND HAVING BODIES WITH RECTANGULAR SECTION, BASED ON THE ABOVE THEORY, FOLLOW.

FIRST—

STRESS IS LESS THAN ONE SIXTH OF ULTIMATE STRENGTH OF THE STEEL IF "L" IS LESS THAN 46"a" OR 23"b" AND IF "A" IS MORE THAN "P" DIVIDED BY ONE EIGHTH OF ULTIMATE STRENGTH OF THE STEEL.

SECOND—

$$S = c_2 \frac{L^2 r}{b} + c_1 \frac{P}{A}$$

VALUES OF c_2 AND c_1

REV. PER MIN.		265	325	375	420
MAIN ROD	c_2 =	0.22	0.33	0.44	0.55
	c_1 =	0.50	0.50	0.40	0.30
SIDE ROD	c_2 =	0.43	0.64	0.85	1.06
	c_1 =	0.50	0.50	0.50	0.50

THE ALLOWABLE STRESSES FOR THE VARIOUS SECTIONS OF ROD ENDS ARE GIVEN IN CONNECTION WITH THE DIAGRAMS FOLLOWING, EXCEPT WHERE THICKNESS OF SECTION IS INDICATED BY THE LETTER "b." THE FIGURES DENOTE MAXIMUM STRESS ALLOWED UNDER END LOAD "P." IF THE MINIMUM AREAS OF THE TWO MEMBERS DIFFER, TAKE DOUBLE THE LESSER AREA FOR "A."

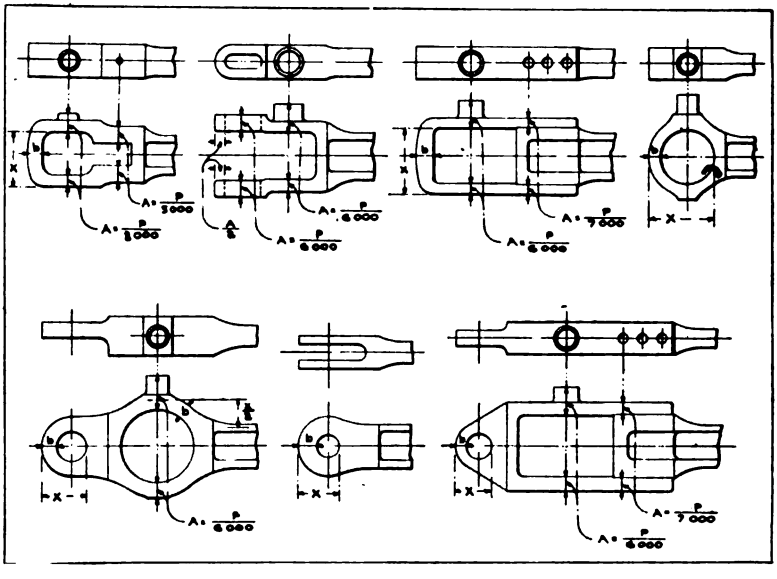
THE MINIMUM AREA AT POINTS INDICATED BY LETTER "b" SHOULD BE—

FOR MAIN RODS— $A = \frac{PX}{30\,000\ b}$

FOR SIDE RODS— $A = \frac{PX}{60\,000\ b}$

IN WHICH "X" IS THE AVERAGE DIAMETER OF EYE OR AVERAGE SPREAD OF JAW MEMBERS

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W. F. KEISEL, JR., Chairman,
H. BARTLETT,
G. LANZA,
H. B. HUNT,
W. E. DUNHAM,
Committee.

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APPENDIX A.

TYPE OF LOCO.	CYL. PRES. 10 000 LBS.	ROD DESIGNATION	AREA OF SECTION	M. INERTIA AXIS HORIZ.	S. MODULUS AXIS HORIZ.	RAD. GYR. AXIS HORIZ.	S. MODULUS AXIS VERT.	RAD. GYR. AXIS VERT.	LENGTH ROD	CRANK RADIUS	WIDTH OF SECTION	DEPTH OF SECTION	THICKNESS OF WEB	DEPTH OF FLUTE	STYLE OF STUB	MIN. AREA	MIN. AREA	AREA	AREA	OFFSET	
T	P	RD.	(A)	I	S.M.	R.G.	s.m.	r.g.	L	r	a	b	c	d	FIG.	(E)	(F)	(G)	(H)	S	REMARKS
442	7.78	M.F.	7.72	42.78	14.72	2.35	3.85	.99	135 3/8"	13"	4"	5 13/16"	2 1/16"	4 3/16"	1	5.03	8.80	8.94	8.94	–	
	7.78	M.B.	9.82	61.87	13.22	2.51	5.18	1.03	135 3/8"	13"	4"	6 3/16"	2 1/16"	4 3/16"	2	7.06	6.53	3.27	6.89	–	
	7.78	S	7.65	44.47	14.82	2.40	4.01	1.02	85"	13"	4"	6"	3/8"	4 3/16"	4 F	5.91	–	–	–	–	
															4 B	6.54	–	–	–		
440	5.67	M.F.	9.12	22.85	10.15	1.58	4.41	.88	132 3/8"	14"	3 1/4"	4 3/16"	1/2"	2"	1	3.94	7.83	4.50	6.00	–	
	5.67	M.B.	5.87	43.67	6.23	2.22	4.42	.85	132 3/8"	14"	3 1/4"	6"	1/2"	3 1/8"	3	–	4.06	11.25	5.30	–	
	5.67	S	7.00	22.56	9.03	1.79	2.37	.82	82"	14"	2 1/2"	5"	1/2"	2 3/4"	4 F	4.87	–	–	–	–	
															4 B	5.25	–	–	–		
462	7.60	M.F.	9.75	42.95	15.62	2.01	5.35	1.05	113 1/8"	14"	4"	5 1/2"	5/8"	3 5/16"	1	5.15	8.50	8.00	8.00	–	
	7.60	M.B.	10.50	72.96	22.27	2.72	5.36	1.01	113 1/8"	14"	4"	7"	5/8"	5"	3	–	5.47	11.25	4.45	–	
	7.60	S1	7.50	32.50	12.50	2.24	2.55	.68	80"	14"	2 1/2"	6"	5/8"	4"	4 F	5.06	–	–	–	1 1/2"	
															5 B	8.50	4.78	–	16.69		
	7.60	S2	7.0	34.33	11.44	2.21	2.13	.61	68"	14"	2 1/2"	6"	5/8"	4"	6 F	6.81	–	–	–	2"	
															4 B	5.06	–	–	–		
280	6.93	M.F.	9.25	21.36	9.49	1.52	3.82	.79	90 7/8"	15"	3"	4 1/2"	3/8"	2"	1	4.16	5.84	5.25	7.87	–	
	6.93	M.B.	15.50	77.54	23.86	2.24	7.10	.96	90 7/8"	15"	4"	6 1/2"	1 3/16"	4"	3	–	4.12	13.50	5.30	–	
	6.93	S1	6.75	11.39	5.06	1.30	1.70	.43	54"	15"	1 1/2"	4 1/2"	–	–	4 F	3.61	–	–	–	6 3/8"	
															6 B	3.00	–	–	–		
	6.93	S2	8.31	15.63	6.58	1.37	2.42	.51	61"	15"	1 3/4"	4 3/4"	–	–	5 F	7.50	2.19	–	13.56	–	
															5 B	7.50	2.19	–	13.56		
	6.93	S3	6.75	11.39	5.06	1.30	1.70	.43	51"	15"	1 1/2"	4 1/2"	–	–	6 F	3.00	–	–	–	13 3/8"	
															4 B	3.61	–	–	–		
280	7.60	M.F.	9.75	42.95	15.62	2.01	5.35	1.05	115 1/2"	15"	4"	5 1/2"	5/8"	3 5/16"	1	5.15	8.50	8.00	8.00	–	
	7.60	M.B.	10.25	64.96	18.99	2.52	5.36	1.02	115 1/2"	15"	4"	6 1/2"	5/8"	4 1/2"	3	–	5.47	11.25	4.45	–	
	7.60	S1	6.19	10.44	4.64	1.30	1.42	.40	53 1/2"	15"	1 3/4"	4 1/2"	–	–	4 F	5.06	–	–	–	2 3/4"	
															6 B	4.78	–	–	–		
	7.60	S2	9.62	24.24	8.82	1.59	2.80	.50	60"	15"	1 3/4"	5 1/2"	–	–	5 F	7.31	4.22	–	16.69	1"	
															5 B	10.06	4.22	–	16.69		
	7.60	S3	6.18	10.44	4.64	1.30	1.42	.40	52"	15"	1 3/16"	4 1/2"	–	–	6 F	4.78	–	–	–	3 1/8"	
															4 B	5.06	–	–	–		
440	4.97	M.F.	5.00	11.92	5.96	1.54	2.06	.85	92 1/2"	13"	3 1/2"	4"	1/2"	3"	1	3.47	5.03	5.95	6.45	–	
	4.97	M.B.	6.75	19.85	8.81	1.71	3.06	.89	92 1/2"	13"	3 1/2"	4 1/2"	1/2"	3"	2	4.62	4.50	2.25	6.89	–	
	4.97	S	5.78	22.73	9.05	1.98	2.61	.89	93"	13"	3 1/2"	5"	3/8"	3 3/4"	4 F	4.22	–	–	–	–	
															4 B	4.27	–	–	–		
442	6.93	M.F.	9.87	56.19	17.29	2.39	3.62	.77	135 1/2"	13"	3 1/2"	6 1/2"	3/4"	4 1/8"	1	7.50	7.50	12.00	9.00	–	
	6.93	M.B.	10.69	84.31	19.06	2.45	3.99	.78	135 1/2"	13"	3 1/2"	6 3/4"	1/2"	4 1/2"	2	7.81	7.12	6.30	9.50	–	
	6.93	S	7.25	34.19	11.83	2.17	2.64	.74	90"	13"	3"	5 3/4"	1/2"	4"	4 F	5.00	–	–	–	–	
															4 B	6.00	–	–	–		
462	9.05	M.F.	12.19	83.00	20.62	2.34	6.07	.99	127"	13"	4"	6 1/2"	3/4"	4 1/2"	1	8.82	8.94	13.41	10.61	–	
	9.05	M.B.	12.94	101.45	27.05	2.80	6.09	.97	127"	13"	4"	7 1/2"	3/4"	5 1/2"	3	–	5.69	15.00	4.76	–	
	9.05	S1	7.50	40.22	13.41	2.32	3.09	.85	73"	13"	3 1/2"	6"	1/2"	4 1/2"	4 F	5.50	–	–	–	2 1/8"	
															5 B	8.12	4.22	–	15.97		
	9.05	S2	7.50	40.22	13.41	2.32	3.09	.85	71 1/2"	13"	3 1/2"	6"	1/2"	4 1/2"	6 F	2.58	–	–	–	2 1/8"	
															4 B	5.50	–	–	–		
280	8.14	M.F.	8.78	44.61	14.87	2.25	3.62	.85	120 5/16"	16"	3 1/2"	6"	3/8"	4 1/2"	1	6.56	9.84	10.94	10.39	–	
	8.14	M.B.	10.12	70.09	20.03	2.65	4.14	.85	120 5/16"	16"	3 1/2"	7"	5/8"	5"	3	–	5.78	15.00	5.94	–	
	8.14	S1	5.50	18.90	7.56	1.85	1.59	.60	57 1/2"	16"	2 1/2"	5"	1/2"	3 1/2"	4 F	4.69	–	–	–	1 5/16"	
															6 B	3.50	–	–	–		
	8.14	S2	7.87	36.91	12.30	2.17	2.28	.66	66"	16"	3"	6"	3/4"	4 1/2"	5 F	6.73	2.58	–	15.97	–	
															7 B	2.81	4.81	15.97	3.68		
	8.14	S3	5.50	18.90	7.56	1.85	1.59	.60	53 3/4"	16"	2 1/2"	5"	1/2"	3 1/2"	6 F	3.50	–	–	–	1 5/16"	
															4 B	4.69	–	–	–		
280	9.27	M.F.	9.97	64.49	19.84	2.54	5.50	1.04	136"	14"	4"	6 1/2"	7/16	4 1/2"	1	6.33	9.56	11.00	11.60	–	
	9.27	M.B.	12.47	93.68	26.29	2.74	7.02	1.06	136"	14"	4"	7 1/2"	7/16	4 1/2"	2	10.20	8.25	4.12	10.07	–	
	9.27	S1	7.50	13.62	6.25	1.44	1.87	.43	57 1/2"	14"	1 1/2"	5"	–	–	4 F	7.00	–	–	–	–	
															6 B	4.35	–	–	–		
	9.27	S2	12.00	36.00	12.00	1.73	4.00	.58	67 1/2"	14"	2"	6"	–	–	5 F	7.31	4.25	–	26.75	–	
															5 B	11.25	4.25	–	26.75		
	9.27	S3	7.50	13.62	6.25	1.44	1.89	.43	55 1/2"	14"	1 1/2"	5"	–	–	6 F	4.55	–	–	–	–	
															4 B	7.00	–	–	–		

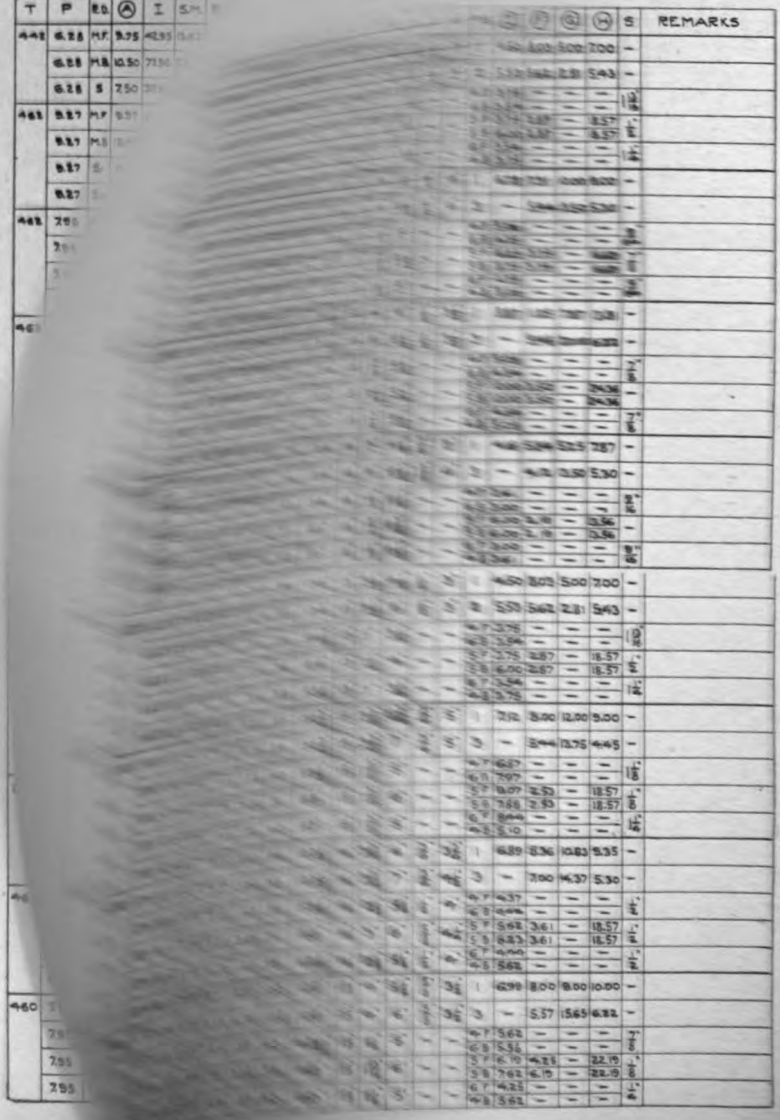
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T	P	E.D.	Ⓐ	I	S.M.	R.G.	sm.	rg.	L	r	a	b	c	d	FIG.	Ⓔ	Ⓕ	Ⓖ	Ⓗ	S	REMARKS
442	6.28	M.F.	9.75	42.95	15.62	2.01	5.35	1.05	121½	14°	4°	5½	½	3½	1	5.15	8.50	9.00	8.00	–	
	6.28	M.B.	10.50	77.96	22.27	2.72	5.36	1.01	121½	14°	4°	7°	½	5°	3	–	5.47	11.25	4.45	–	
	6.28	S	7.50	32.50	12.50	2.24	2.55	.66	84°	14°	2½	6°	½	4°	4 F	5.06	–	–	–	⅜	
															4 B	7.44	–	–	–		
462	9.27	M.F.	9.97	64.49	19.84	2.54	5.50	1.04	125°	15°	4°	6½	2/4	4½	1	8.31	8.37	12.87	11.73	–	
	9.27	M.B.	12.47	93.68	26.29	2.74	7.02	1.06	125°	15°	4°	7½	2/4	4½	2	10.62	9.00	4.50	9.07	–	
	9.27	S.	6.87	30.38	11.05	2.12	2.67	.79	83°	15°	3½	5½	½	4°	4 F	5.50	–	–	–	3/8	
															5 B	7.31	3.73	–	28.75		
	9.27	S₂	6.87	30.38	11.05	2.12	2.67	.79	70°	15°	3½	5½	½	4°	6 F	4.84	–	–	–	3/8	
															4 B	5.50	–	–	–		
442	7.95	M.F.	8.87	22.99	11.99	1.84	4.12	.90	115½	13°	3½	5°	⅜	3°	1	3.94	7.44	8.92	7.44	–	
	7.95	M.B.	10.84	74.36	21.34	2.62	4.65	.87	119½	13°	3½	7°	⅜	4½	3	–	4.76	11.00	4.45	–	
	7.95	S.	7.12	29.02	11.05	2.02	3.08	.87	78°	13°	3½	5½	½	3½	4 F	5.00	–	–	–		
															5 B	7.17	3.32	–	16.27		
	7.95	S₂	7.12	29.02	11.05	2.02	3.08	.87	68°	13°	3½	5½	½	3½	6 F	3.81	–	–	–		
															4 B	5.00	–	–	–		
462	6.93	M.F.	9.55	60.15	19.60	2.09	4.32	.89	121½	14°	3½	5½	⅜	3½	1	4.84	13.08	3.69	6.73	–	
	6.93	M.B.	10.17	60.04	18.47	2.43	4.39	.87	121½	14°	3½	6½	⅛	4½	3	–	4.20	12.50	4.45	–	
	6.93	S.	6.50	28.26	10.28	2.08	2.28	.72	82°	14°	3°	5½	½	4°	4 F	4.80	–	–	–		
															7 B	3.08	3.68	15.97	3.33	7/8	
	6.93	S₂	6.50	28.26	10.28	2.08	2.28	.72	84°	14°	3°	5½	½	4°	6 F	3.36	–	–	–		
															4 B	6.00	–	–	–	1/4	
280	6.93	M.F.	8.25	21.36	9.49	1.52	3.82	.79	124°	15°	3°	4½	2/8	2°	1	4.16	5.84	5.25	7.87	–	
	6.93	M.B.	15.50	72.54	23.88	2.24	2.10	.96	124°	15°	4°	6½	1⅛	4°	3	–	4.12	12.50	5.30	–	
	6.93	S.	6.75	11.39	5.06	1.30	1.70	.43	51°	15°	1½	4½	–	–	4 F	3.61	–	–	–	3/8	
															6 B	3.00	–	–	–		
	6.93	S₂	8.31	15.63	6.58	1.37	2.42	.51	61°	15°	1½	4½	–	–	5 F	6.00	2.18	–	13.56	–	
															5 B	6.00	2.19	–	13.56		
	6.93	S₃	6.75	11.39	5.06	1.30	1.70	.43	51°	15°	1½	4½	–	–	6 F	3.00	–	–	–	9/16	
															4 B	3.61	–	–	–		
060	4.96	M.F.	8.50	27.85	11.73	1.81	4.68	1.00	119½	13°	4°	4½	½	3°	1	5.15	8.50	9.00	8.00	–	
	4.96	M.B.	9.12	49.61	16.54	2.33	4.69	1.01	119½	13°	4°	6°	½	4½	3	–	5.47	11.25	4.45	–	
	4.96	S.	6.19	10.44	4.64	1.30	1.42	.40	68°	13°	1⅛	4½	–	–	4 F	5.06	–	–	–	3/8	
															6 B	4.75	–	–	–		
	4.96	S₂	8.75	18.23	7.30	1.44	2.55	.50	53½	13°	1½	5°	–	–	5 F	5.06	3.75	–	16.69	3/8	
															4 B	6.75	–	–	–		
280	6.93	M.F.	8.69	35.76	13.01	2.03	3.56	.82	89½	14°	3½	5½	⅜	3½	1	5.56	5.62	9.92	6.94	–	
	6.93	M.B.	9.31	55.23	17.01	2.44	3.58	.79	99½	14°	3½	6½	⅜	4½	3	–	4.30	11.25	4.45	–	
	6.93	S.	6.12	26.13	9.50	2.07	1.92	.66	90°	14°	2½	5½	½	4°	4 F	4.12	–	–	–	11/16	
															5 B	6.75	3.44	–	14.74		
	6.93	S₂	5.87	20.61	8.24	1.87	1.99	.67	74½	14°	2½	5°	½	3½	6 F	2.94	–	–	–	¾	
															4 B	4.37	–	–	–		
260	6.28	M.F.	7.87	20.41	9.07	1.61	3.35	.80	117⅞	14°	3°	4½	½	2½	1	3.94	5.05	4.50	6.00	–	
	6.28	M.B.	8.50	38.59	3.42	2.13	3.40	.77	117½	14°	3°	5¾	½	3½	3	–	3.66	11.25	4.76	–	
	6.28	S.	6.75	11.39	5.06	1.30	1.70	.43	74°	14°	1½	4½	–	–	4 F	3.66	–	–	–		
															5 B	4.47	2.18	–	13.56	–	
	6.28	S₂	7.31	12.34	5.48	1.30	1.98	.47	73½	14°	1⅝	4½	–	–	6 F	2.62	–	–	–		
															4 B	3.66	–	–	–	–	
460	6.28	M.F.	7.90	21.38	9.50	1.69	3.50	.91	115¼	14°	3½	4½	½	2½	1	4.56	6.11	5.25	7.00	–	
	6.28	M.B.	8.25	43.81	4.60	2.51	3.60	.87	115½	14°	3½	6°	½	4½	3	–	3.66	11.25	4.76	–	
	6.28	S.	6.75	11.39	5.06	1.30	1.70	.43	72°	14°	1½	4½	–	–	4 F	3.66	–	–	–		
															5 B	4.47	2.19	–	13.56	–	
	6.28	S₂	7.31	12.34	5.48	1.30	1.98	.47	62°	14°	1⅝	4½	–	–	6 F	2.62	–	–	–		
															4 B	3.66	–	–	–	–	
460	7.95	M.F.	11.25	37.12	14.84	1.82	6.62	1.09	111⅛	14°	4°	5°	½	2½	1	5.12	8.53	7.00	11.00	–	
	7.95	M.B.	12.35	87.76	25.07	2.63	6.69	1.05	111⅛	14°	4°	7°	½	4½	3	–	4.50	15.75	5.30	–	
	7.95	S.	9.84	22.61	8.61	1.51	3.06	.54	75°	14°	1½	5½	–	–	4 F	5.23	–	–	–		
															5 B	8.00	3.50	–	18.57	–	
	7.95	S₂	9.84	22.61	8.61	1.51	3.06	.54	63°	14°	1½	5½	–	–	6 F	4.30	–	–	–		
															4 B	5.23	–	–	–	–	

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T	P	RD	Ⓐ	I	S.M.	R.G.	sm	rg.	L	r	a	b	c	d	FIG.	Ⓔ	Ⓕ	Ⓖ	Ⓗ	S	REMARKS
060	5.65	M.F.	7.67	24.81	9.92	1.80	2.70	.73	70°	13°	3°	5°	2½°	3½°	1	6.00	6.53	8.57	7.87	–	
	5.65	M.S.	8.44	38.61	13.20	2.17	2.73	.70	70°	15°	3°	6°	2½°	4½°	3	–	4.64	10.00	3.68	–	
	5.65	S1	10.00	20.83	8.33	1.68	3.33	.58	70°	13°	2°	5°	–	–	4 F 5 B	4.37 6.37	– 3.00	– –	– 13.56	1°	
	5.65	S4	10.00	20.83	8.33	1.68	3.33	.58	52½°	13°	2°	5°	–	–	6 F 4 B	4.00 5.25	– –	– –	– –	⅝°	
360	6.93	M.F.	8.50	27.85	11.73	1.81	4.68	1.00	85⅛°	14°	4°	4¾°	⅛°	3°	1	5.15	8.50	9.00	8.00	–	
	6.93	M.S.	9.12	43.61	16.54	2.33	4.69	1.01	85⅛°	14°	4°	6°	½°	4½°	3	–	5.47	11.25	4.45	–	
	6.93	S1	7.25	41.03	12.93	2.41	2.12	.60	90°	14°	2⅛°	6⅛°	½°	4⅛°	4 F 5 B	5.06 8.12	– 6.47	– –	– 16.69	1⅜°	
	6.93	S4	7.25	42.03	12.93	2.41	2.12	.60	92½°	14°	2⅛°	6⅛°	⅛°	4⅛°	6 F 4 B	4.25 5.06	– –	– –	– –	⅞°	
260	5.97	M.F.	7.87	20.41	9.07	1.61	3.39	.80	110⅜°	14°	3°	4½°	½°	2¼°	1	3.84	5.05	4.50	6.00	–	
	5.97	M.S.	8.50	38.39	13.42	2.13	3.40	.77	110⅜°	14°	3°	5¾°	½°	3½°	3	–	3.66	11.25	4.76	–	
	5.97	S1	6.75	11.38	5.06	1.30	1.70	.43	74°	14°	1½°	4½°	–	–	4 F 5 B	3.66 4.47	– 2.19	– –	– 13.56	–	
	5.97	S4	2.31	12.34	5.48	1.30	1.98	.47	66°	14°	1⅝°	4½°	–	–	6 F 4 B	2.62 3.66	– –	– –	– –	–	
460	7.60	M.F.	9.75	42.35	15.62	2.01	5.35	1.05	112½°	14°	4°	5½°	½°	3½°	1	5.15	8.50	9.00	8.00	–	
	7.60	M.S.	10.80	72.96	22.27	2.72	5.36	1.01	112½°	14°	4°	7°	½°	5°	3	–	5.47	11.25	4.45	–	
	7.60	S1	7.50	32.50	12.50	2.24	2.55	.68	73°	14°	2¾°	6°	½°	4°	4 F 5 B	5.06 8.50	– 4.78	– –	– 16.69	1¾°	
	7.60	S4	7.50	32.50	12.50	2.24	2.55	.68	81°	14°	2¾°	6°	½°	4°	6 F 4 B	6.81 5.06	– –	– –	– –	¼°	
460	6.93	M.F.	8.87	28.99	11.99	1.84	4.12	.90	124¾°	13°	3½°	5°	⅝°	3°	1	4.96	7.64	9.92	7.44	–	
	6.93	M.S.	9.81	52.27	17.93	2.44	4.13	.86	124¾°	13°	3½°	6⅛°	⅝°	4½°	2	6.94	6.72	5.30	8.77	–	
	6.93	S1	6.12	26.13	9.50	2.07	1.92	.66	82°	13°	2¾°	5½°	½°	4°	4 F 7 B	5.16	–	–	–	⅞°	
	6.93	S4	6.12	26.13	9.50	2.07	1.92	.66	84½°	13°	2¾°	5½°	½°	4°	6 F 4 B	5.16	–	–	–	½°	
280	6.28	M.F.	6.75	22.33	9.92	1.82	3.07	.89	122½°	12°	3½°	4½°	½°	3°	1	4.50	8.03	5.00	7.00	–	
	6.28	M.S.	12.00	56.25	18.75	2.17	6.14	.95	122½°	12°	3½°	6°	½°	3°	2	5.53	5.62	2.81	5.43	–	
	6.28	S1	3.25	2.86	1.76	.94	.54	.29	50⅞°	12°	1°	3½°	–	–	4 F 6 B	3.75 3.54	– –	– –	– –	1⅛°	
	6.28	S2	5.00	6.66	3.33	1.15	1.04	.36	60°	12°	1½°	4°	–	–	5 F 5 B	3.75 6.00	2.87 2.87	– –	8.57 18.57	⅛°	
	6.28	S3	3.25	2.86	1.76	.54	.54	.29	49½°	12°	1°	3½°	–	–	6 F 4 B	3.54 3.75	– –	– –	– –	1½°	
280	6.93	M.F.	9.87	56.18	17.29	2.39	3.62	.77	133°	15°	3½°	6⅛°	¾°	4⅛°	1	7.50	7.50	12.00	9.00	–	
	6.93	M.S.	10.62	64.31	19.06	2.45	3.99	.78	133°	15°	3½°	6¾°	½°	4⅛°	2	7.81	7.12	6.30	9.50	–	
	6.93	S1	2.50	24.16	8.71	1.79	1.62	.47	55°	15°	2°	5½°	1°	3½°	4 F 6 B	4.47 3.10	– –	– –	– –	1⅛°	
	6.93	S2	3.25	4.27	3.21	2.11	2.23	.55	63°	15°	2⅛°	6¼°	1°	4½°	5 F 7 B	6.12 4.50	4.50 3.83	– 13.56	13.56 4.07	–	
	6.93	S3	2.50	24.16	8.71	1.79	1.62	.47	50½°	15°	2°	5½°	1°	3⅛°	6 F 4 B	3.10 4.47	– –	– –	– –	1⅛°	
280	7.60	M.F.	10.44	54.23	16.89	2.28	3.32	.72	139°	16°	3½°	6½°	1°	4¾°	1	6.00	6.53	8.75	7.87	–	
	7.60	M.S.	11.25	63.20	18.72	2.61	3.76	.74	139°	16°	3½°	6¾°	1°	4¾°	3	–	4.64	10.00	3.68	–	
	7.60	S1	7.31	12.34	5.48	1.30	1.98	.47	58°	16°	1⅝°	4½°	–	–	4 F 6 B	3.75 5.06	– –	– –	– –	½°	
	7.60	S2	8.62	24.26	8.82	1.59	2.80	.50	69°	16°	1½°	5½°	–	–	5 F 5 B	5.00 3.86	4.84 4.94	– –	18.57 18.57	⅞°	
	7.60	S3	6.75	11.35	5.06	1.30	1.70	.43	57¾°	16°	1½°	4½°	–	–	6 F 4 B	5.06 5.16	– –	– –	– –	–	
280	9.05	M.F.	11.75	58.49	19.83	2.25	6.69	1.07	90⅞°	15°	4°	6°	½°	3½°	1	8.87	7.12	22.50	4.62	–	
	9.05	M.S.	13.75	78.04	24.32	2.40	8.02	1.08	90⅞°	15°	4°	6½°	½°	3½°	3	–	5.93	20.00	6.32	–	
	9.05	S1	9.84	22.61	8.61	1.51	3.06	.54	54°	15°	1⅞°	5¼°	–	–	4 F 6 B	5.08 4.54	– –	– –	– –	⅞°	
	9.05	S2	11.16	23.62	9.76	1.51	3.95	.61	63°	15°	2⅛°	5¼°	–	–	5 F 5 B	10.00 10.00	3.50 3.50	– –	24.36 24.36	–	
	9.05	S3	9.84	22.61	8.61	1.51	3.06	.54	51°	15°	1⅞°	5¼°	–	–	6 F 4 B	4.54 5.08	– –	– –	– –	⅞°	

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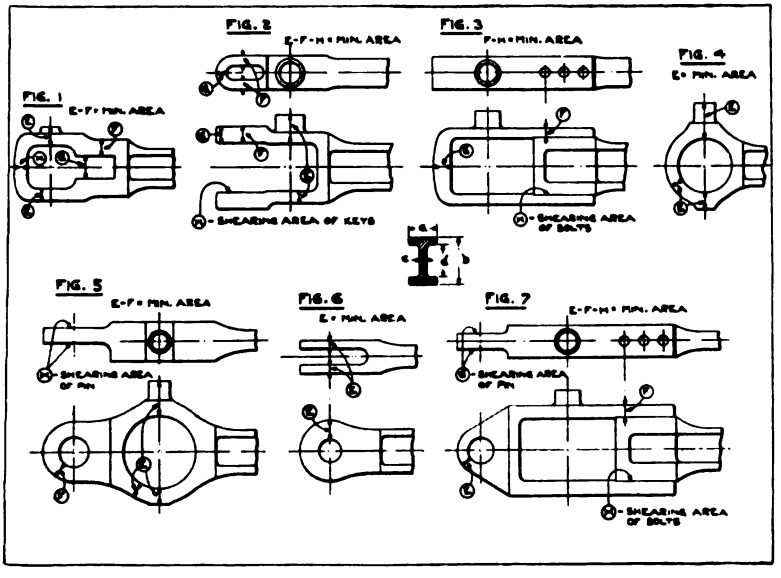


T	P	RD	Ⓐ	I	S.M.	R.G.	s.m.	rg.	L	r	a	b	c	d	FIG.	Ⓔ	Ⓕ	Ⓖ	Ⓗ	S	REMARKS
442	6.28	M.F.	8.75	28.23	11.29	1.80	3.59	.82	126½°	13°	3½°	5°	2½°	3°	1	4.96	7.64	9.92	7.44	–	
	6.28	M.B.	10.25	66.85	19.10	2.55	3.63	.76	126½°	13°	3½°	7°	2½°	5°	2	5.94	6.56	5.00	2.40	–	
	6.28	S	6.50	28.26	10.28	2.08	2.28	.72	84°	13°	3°	5½°	½°	4°	4F	5.25	–	–	–	–	
															4B	6.75	–	–	–		
468	8.17	M.F.	9.62	38.71	14.04	2.05	4.15	.87	108°	14°	3½°	5½°	2½°	3½°	1	6.23	8.05	11.91	8.93	–	
	8.17	M.B.	11.44	79.23	22.64	2.63	4.69	.85	108°	14°	3½°	7°	2½°	4½°	3	–	5.44	13.75	4.45	–	
	8.17	S1	6.56	25.12	9.57	1.96	2.23	.68	78°	14°	2½°	5½°	½°	3½°	4F	4.69	–	–	–	2½	
															5B	7.50	2.58	–	15.97		
	8.17	S2	6.56	25.12	9.57	1.96	2.23	.68	67°	14°	2½°	5½°	½°	3½°	6F	3.09	–	–	–	2½	
															4B	4.69	–	–	–		
462	8.31	M.F.	10.50	51.50	17.17	2.21	4.76	.92	120°	14°	3½°	6°	2½°	4°	1	6.89	8.36	10.83	9.35	–	
	8.31	M.B.	11.35	75.54	21.70	2.60	4.78	.89	120°	14°	3½°	7°	3½°	5°	3	–	2.00	14.37	5.30	–	
	8.31	S1	7.37	38.01	12.67	2.27	2.65	.73	81°	14°	3°	6°	½°	4½°	4F	5.00	–	–	–	½	
															5B	7.78	3.61	–	18.57		
	8.31	S2	7.37	38.01	12.67	2.27	2.65	.73	69½°	14°	3°	6°	½°	4½°	6F	4.50	–	–	–	½	
															4B	5.00	–	–	–		
462	7.96	M.F.	8.75	32.81	13.75	2.08	4.10	.91		14°	3½°	5½°	½°	3½°	1					–	
	7.96	M.B.	10.50	52.23	17.43	2.23	5.12	.92		14°	3½°	6°	½°	3½°	3					–	
	7.96	S1	6.50	32.21	10.74	2.23	1.86	.60	84°	14°	2½°	6°	½°	4½°	4F	5.06	–	–	–	2½	
															5B	6.25	3.75	–	16.69		
	7.96	S2	6.50	32.21	10.74	2.23	1.86	.60	87°	14°	2½°	6°	½°	4½°	6F	4.75	–	–	–	2½	
															4B	5.06	–	–	–		
280	6.28	M.F.	6.75	22.33	9.92	1.82	3.07	.89	119½°	14°	3½°	4½°	½°	3°	1	4.50	8.03	5.00	7.00	–	
	6.28	M.B.	12.00	56.25	18.75	2.17	6.14	.95	119½°	14°	3½°	6°	½°	3°	2	5.53	5.62	2.81	5.43	–	
	6.28	S1	3.25	2.86	1.76	.94	.54	.29	50⅞°	14°	1°	3½°	–	–	4F	3.75	–	–	–	13¼	
															6B	3.54	–	–	–		
	6.28	S2	5.00	6.66	3.33	1.15	1.04	.36	60°	14°	1½°	4°	–	–	5F	3.75	2.87	–	18.57	½	
															5B	6.00	2.87	–	18.57		
	6.28	S3	3.25	2.86	1.76	.94	.54	.29	49½°	14°	1°	3½°	–	–	6F	3.54	–	–	–	1¼	
															4B	3.75	–	–	–		
448	6.93	M.F.	8.66	26.93	10.84	1.75	3.58	.82	127°	13°	3½°	4⅞°	2½°	2⅞°	3	–	4.43	8.34	3.68	–	
	6.93	M.B.	10.25	66.85	19.10	2.55	3.63	.76	127°	13°	3½°	7°	2½°	5°	2	8.02	6.87	4.06	7.57	–	
	6.93	S	6.56	25.12	9.57	1.96	2.23	.68	84°	13°	2½°	5½°	½°	3½°	4F	5.06	–	–	–	2½	
															4B	5.57	–	–	–	32	
460	6.60	M.F.	9.00	42.00	14.00	2.16	3.08	.72	118°	14°	3°	6°	2½°	4°	1	5.95	7.25	8.93	7.94	–	
	6.60	M.B.	10.50	56.66	17.43	2.32	3.84	.74	118°	14°	3°/	6½°	2½°	4°	2	7.31	5.26	4.33	7.46	–	
	6.60	S1	6.56	25.18	9.57	1.96	2.23	.68	83°	14°	2¾°	5½°	½°	3½°	4F	4.37	–	–	–		
															5B	6.25	2.84	–	13.56	¼	
	6.60	S2	6.56	25.12	9.57	1.96	2.23	.68	87°	14°	2¾°	5½°	½°	3½°	6F	3.75	–	–	–		
															4B	4.37	–	–	–	¼	
462	7.96	M.F.	9.62	38.71	14.04	2.05	4.15	.87	118°	15°	3½°	5½°	2½°	3½°	1	6.56	6.87	8.75	7.87	–	
	7.96	M.B.	11.37	53.17	17.72	2.16	5.17	.89	118°	15°	3½°	6°	2½°	3½°	2	6.75	6.65	2.50	3.12	–	
	7.96	S1	9.75	29.25	9.75	1.73	2.76	.47	78°	15°	1⅞°	6°	–	–	4F	3.20	–	–	–		
															7B	3.28	5.03	23.43	2.98	2½	
	7.96	S2	9.00	27.00	9.00	1.73	2.25	.43	66½°	15°	1½°	6°	–	–	6F	4.64	–	–	–		
															4B	3.20	–	–	–	2¼	
462	9.82	M.F.	10.78	46.77	16.23	2.08	4.80	.91	113½°	14°	3½°	5½°	⅞°	3⅜°	1	9.00	13.00	10.69	11.87	–	
	9.82	M.B.	12.66	63.83	20.42	2.25	5.97	.94	113½°	14°	3⅜°	6¼°	⅞°	3⅜°	3	–	7.25	15.00	12.12	–	
	9.82	S1	12.19	42.91	13.20	1.88	3.81	.54	80°	14°	1⅞°	6½°	–	–	4F	7.00	–	–	–		
															5B	10.69	4.50	–	30.94	5⅛	
	9.82	S2	9.75	29.25	9.75	1.73	2.76	.47	67⅜°	14°	1⅝°	6°	–	–	6F	6.25	–	–	–		
															4B	2.00	–	–	–	5⅛	
280	6.60	M.F.	8.94	22.30	9.39	1.58	2.96	.73	120°	16°	3¼°	4¾°	1¼°	3¼°	1	6.19	8.44	11.25	7.87	–	
	6.60	M.B.	8.06	35.50	12.35	2.10	2.73	.74	120°	16°	3¼°	5¾°	¾°	4¼°	2	6.75	5.78	5.08	3.55	–	
	6.60	S1	8.50	12.79	6.02	1.23	2.83	.58	53¼°	16°	2°	4¼°	–	–	4F	4.06	–	–	–		
															6B	4.22	–	–	–	1½	
	6.60	S2	7.22	21.39	8.56	1.72	1.97	.59	62°	16°	2½°	5°	⅞°	3¼°	7F	3.00	3.66	13.56	3.65		
															7B	3.00	4.69	13.56	3.69	–	
	6.60	S3	6.00	18.08	7.23	1.73	1.38	.51	57¼°	16°	2¼°	5°	¾°	3½°	6F	4.22	–	–	–		
															4B	5.00	–	–	–	⅛	

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T	P	R.D.	Ⓐ	I	S.M.	R.G.	s.m.	r.g.	L	r	a	b	c	d	Fig.	Ⓔ	Ⓕ	Ⓖ	Ⓗ	S	REMARKS
280	6.28	M.F.	9.00	42.00	4.00	2.16	3.03	.72	125°	14°	3°	6°	3/4°	4°	1	5.95	7.25	8.93	7.94	–	
	6.28	M.B.	10.50	58.66	7.43	2.32	3.84	.74	125°	14°	3°	6 1/2°	3/4°	4°	2	7.31	5.26	4.33	7.46	–	
	6.28	S1	6.00	8.00	4.00	1.15	1.50	.43	54°	14°	1 1/2°	4°	–	–	4 F	3.44	–	–	–	5/16"	
															4 B	3.75	–	–	–		
	6.28	S2	7.50	15.62	6.25	1.44	1.87	.43	66°	14°	1 1/2°	5°	–	–	5 F	5.25	2.84	–	13.56	–	
															5 B	6.00	2.84	–	13.56		
	6.28	S3	6.00	8.00	4.00	1.15	1.50	.43	55°	14°	1 1/2°	4°	–	–	6 F	3.75	–	–	–	5/16"	
															4 B	3.44	–	–	–		
280	7.20	M.F.	10.00	48.33	6.11	2.20	4.16	.85	118°	14°	3 1/2°	6°	3/4°	4°	1	5.95	7.25	8.93	7.94	–	
	7.20	M.B.	11.75	65.43	8.13	2.36	5.18	.88	118°	14°	3 1/2°	6 1/2°	3/4°	4°	2	7.31	6.38	5.13	7.46	–	
	7.20	S1	6.00	8.00	4.00	1.15	1.50	.43	54 1/2°	14°	1 1/2°	4°	–	–	4 F	3.44	–	–	–	5/16"	
															4 B	4.06	–	–	–		
	7.20	S2	8.12	16.93	6.77	1.44	2.20	.47	60°	14°	1 5/8°	5°	–	–	5 F	5.25	3.06	–	18.24	1/4"	
															5 B	6.75	3.06	–	18.24		
	7.20	S3	6.00	8.00	4.00	1.15	1.50	.43	49 1/2°	14°	1 1/2°	4°	–	–	6 F	4.06	–	–	–	5/16"	
															4 B	3.44	–	–	–		
280	7.60	M.F.	10.75	68.66	20.34	2.53	4.75	.94	143°	15°	4°	6 3/4°	3/4°	5°	1	7.12	8.00	12.00	9.00	–	
	7.60	M.B.	11.75	80.48	22.99	2.62	5.42	.96	143°	15°	4°	7°	3/4°	5°	3	–	5.02	13.57	6.21	–	
	7.60	S1	7.50	22.50	7.50	1.73	1.56	.36	59°	15°	1 1/2°	6°	–	–	4 F	4.67	–	–	–	7/16	
															4 B	4.52	–	–	–		
	7.60	S2	8.94	31.97	9.68	1.88	2.05	.40	68°	15°	1 5/8°	6 1/2°	–	–	5 F	5.47	4.22	–	18.24	1/4"	
															5 B	4.22	4.01	18.24	3.87		
	7.60	S3	7.81	25.93	7.83	1.81	1.63	.36	54 1/4°	15°	1 1/2°	6 1/2°	–	–	6 F	4.12	–	–	–	1"	
															4 B	4.12	–	–	–		
280	8.31	M.F.	8.62	40.12	13.95	2.16	3.62	.86	128°	16°	3 1/2°	5 3/4°	5/16°	4°	1	6.28	6.94	10.55	9.76	–	
	8.31	M.B.	10.84	74.36	21.24	2.62	4.65	.87	128°	16°	3 1/2°	7°	5/16°	4 3/4°	3	–	6.78	13.75	5.30	–	
	8.31	S1	5.50	18.90	7.56	1.85	1.59	.60	57 1/2°	16°	2 1/2°	5°	1/2°	3 1/2°	4 F	4.37	–	–	–	5/16"	
															4 B	3.50	–	–	–		
	8.31	S2	6.12	26.13	9.50	2.07	1.92	.66	66°	16°	2 3/4°	5 1/2°	1/2°	4°	5 F	6.91	3.44	–	14.20	–	
															5 B	6.09	3.44	–	14.20		
	8.31	S3	5.50	18.90	7.56	.85	1.59	.60	67°	16°	2 1/2°	5°	1/2°	3 1/2°	6 F	3.50	–	–	–	1/4"	
															4 B	4.81	–	–	–		
260	6.21	M.F.	10.00	48.33	16.11	2.20	4.16	.85	134 1/2°	16°	3 1/2°	6°	3/4°	4°	1	5.44	8.48	11.91	7.94	–	
	6.28	M.B.	10.75	71.40	20.40	2.58	4.18	.83	134 1/2°	16°	3 1/2°	7°	3/4°	5°	3	–	5.86	11.25	4.43	–	
	6.21	S1	8.31	15.63	6.58	1.37	2.42	.51	63 1/2°	16°	1 3/4°	4 3/4°	–	–	4 F	4.37	–	–	–	1/4"	
															4 B	4.00	–	–	–		
	6.28	S2	10.50	31.50	10.50	1.73	3.06	.51	72°	16°	1 3/4°	6°	–	–	5 F	5.25	2.59	–	13.85	1/4"	
															4 B	5.69	–	–	–		
462	7.60	M.F.	9.62	38.72	14.08	2.01	4.15	.87	122°	14°	3 1/2°	5 1/2°	3/4°	3 1/2°	1	5.95	5.64	8.92	6.95	–	
	7.60	M.B.	10.75	71.40	20.40	2.58	4.18	.83	122°	14°	3 1/2°	7°	3/4°	5°	3	–	9.69	13.75	5.30	–	
	7.60	S1	6.81	31.57	10.93	2.15	2.24	.67	84°	14°	2 3/4°	5 3/4°	1/2°	4°	4 F	4.37	–	–	–	1/8"	
															5 B	2.72	3.44	–	14.20		
	7.60	S2	6.81	31.57	10.93	2.15	2.24	.67	73 1/2°	14°	2 3/4°	5 3/4°	1/2°	4°	6 F	3.50	–	–	–	1/8"	
															4 B	4.37	–	–	–		
462	8.35	M.F.	10.50	51.50	17.17	2.21	4.76	.92	122°	13°	3 3/4°	6°	3/4°	4°	1	5.33	9.43	11.91	8.43	–	
	8.35	M.B.	11.25	75.94	21.70	2.60	4.78	.89	122°	13°	3 3/4°	7°	3/4°	5°	3	–	5.03	13.75	6.21	–	
	8.35	S1	6.75	21.50	8.60	1.48	1.98	.64	78°	13°	2 3/4°	5°	3/4°	3 1/2°	4 F	6.02	–	–	–	–	
															7 B	4.22	4.48	11.57	4.45		
	8.35	S2	6.75	21.50	8.60	1.48	1.98	.64	64 1/4°	13°	2 3/4°	5°	3/4°	3 1/2°	6 F	4.78	–	–	–	–	
															4 B	6.02	–	–	–		
462	6.93	M.F.	8.19	24.92	10.49	1.74	3.64	.88	111 3/4°	14°	3 1/2°	4 3/4°	11/16°	3°	3	–	3.78	8.00	3.68	–	
	6.93	M.B.	9.75	48.00	16.00	2.22	4.18	.87	111 3/4°	14°	3 1/2°	6°	11/16°	4°	3	–	4.69	11.25	4.45	–	
	6.93	S1	5.87	20.61	8.24	1.87	1.92	.67	78°	14°	2 3/4°	5°	1/2°	3 1/2°	4 F	5.00	–	–	–	1/4"	
															7 B	4.69	4.30	13.56	8.45		
	6.93	S2	5.87	20.61	8.24	1.87	1.92	.67	67 1/2°	14°	2 3/4°	5°	1/2°	3 1/2°	6 F	5.06	–	–	–	3/16"	
															4 B	5.00	–	–	–		
440	6.93	M.F.	8.19	24.92	10.49	1.74	3.64	.88	116 3/16°	13°	3 1/2°	4 3/4°	11/16°	3°	3	–	3.78	8.00	3.68	–	
	6.93	M.B.	9.75	48.00	16.00	2.22	4.18	.87	116 3/16°	13°	3 1/2°	6°	11/16°	4°	3	–	4.68	11.25	4.45	–	
	6.93	S1	5.87	20.61	8.24	1.87	1.92	.67	82°	13°	2 3/4°	5°	1/2°	3 1/2°	4 F	4.69	–	–	–	–	
															7 B	3.44	4.30	13.56	8.45		
	6.93	S2	5.87	20.61	8.24	1.87	1.92	.67	85 11/32°	13°	2 3/4°	5°	1/2°	3 1/2°	6 F	3.50	–	–	–	1/4"	
															4 B	4.69	–	–	–		

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SPECIFICATIONS FOR STEEL IN RODS & STRAPS
IN USE BY VARIOUS RAILROADS & LOCOMOTIVE WORKS

CARBON P.C.	MANGANESE MAX. P.C.	SILICON MAX. P.C.	PHOSPHORUS MAX. P.C.	SULPHUR MAX. P.C.	COPPER MAX. P.C.	ULT. TEN. STR. LBS. PER SQ. INCH	ELONGATION P.C. IN INCHES	REMARKS
.25 TO .40	.60	—	.06	.06	—	70 000	20 IN 2	FOR ROD STRAPS
.35 TO .50	.80	—	.05	.05	—	80 000	17 IN 2	FOR RODS
.35 TO .45	.80	—	.04 ACID .03 BASIC	.04 ACID .03 BASIC	—	80 000	20 IN 2	ACID BASIC } ANNEALED
.35 TO .50	.60	.25	.05	.05	.03	80 000	——	——
.20 TO .40	.05	—	.05	.045	—	55 000 TO 65 000	20 IN 2	FOR ROD STRAPS
.35 TO .50	.05	—	.05	.045	—	70 000 TO 80 000	17 IN 2.	FOR RODS
ABOUT .40	.60	—	.05	.05	—	80 000	20 IN 2	FOR RODS
.35 TO .50	.60	—	.05	.05	—	——	——	FOR RODS
.35 TO .50	.55	—	.04	.04	—	——	——	FOR RODS & STRAPS ANNEALED
——	.60	—	.05	.05	—	80 000	20 IN 2	ANNEALED
.35 TO .50	.60	—	.04	.04	—	80 000	18 IN 2	FOR RODS & STRAPS
.35 TO .50	.60	—	.06	.05	—	85 000	22 IN 2	FOR RODS 3 IN. BELOW AND 10 PC. ABOVE ALLOWED FOR PHYSICAL REQUIREMENTS
.35 TO .50	.55	.20	.04	.04	—	80 000	20 IN 2	FOR RODS FORGINGS
.35 TO .50	.55	.20	.04	.04	—	75 000	15 IN 2	FOR RODS BLOOMS
.35 TO .50	.60	.25	.05	.05	.03	80 000	——	——

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FORMULAE FOR CALCULATING STRESSES IN MAIN & PARALLEL RODS

IN USE BY VARIOUS RAILROADS & LOCOMOTIVE WORKS

		REMARKS
A = AREA OF SECTION B = DIA. OF CYLINDERS IN INCHES P = DIRECT COMPRESSION STRESS R = METTIA STRESS. G = ACCELERATION OF GRAVITY = 32.16 L = LENGTH OF ROD IN INCHES (R TO C) M = MAX. BENDING MOMENT W = LOAD ON ROD IN LBS. P = EFFECTIVE PRESSURE AT MID STROKE S = CRANK RAD. IN FEET S = MODULUS OF SECTION V = VELOCITY OF CRANK PIN IN FEET PER SECOND W = AVERAGE WEIGHT OF ROD BODY PER INCH LBS.	$P = \frac{P}{A}$ $P = 1.55$ TO $1.65 \frac{\pi}{4} D^2 R$ $R = \frac{M}{S}$ $M = \frac{W V^2 L^2}{166 S}$	THESE FORMULAE FOR MAIN ROD ONLY.

		REMARKS
A = AREA OF SECTION TAKEN A1 = LEAST AREA IN LENGTH OF ROD BODY A2 = AREA OF RIVETS D = PER CENT OF R.P. DUE TO SPEED & CUT OFF P = SAFE STRESS AS A STRUT P1 = DIRECT COMPRESSION STRESS R = INERTIA STRESS G = ACCELERATION OF GRAVITY = 32.16 L = LENGTH OF ROD IN INCHES P = LOAD ON MAIN ROD IN LBS. = $A_1 \times R$ R = " " PAR. " " R = SAFE PRESSURE S = LEAST RAD. OF GYRATION S = CRANK RAD. IN FEET S = STROKE IN INCHES V = VELOCITY OF CRANK PIN IN FEET PER SECOND W = MODULUS OF SECTION TAKEN (MAIN ROD.) R IN PER CENT P FIG. 1 FIG. 2 FIG. 3 FIG. 4 A=36 A=40 A=33 A=36	$P = \frac{P}{A_1} = 8000$ LBS. WHEN $\frac{L}{R} = 100$ TO 150 (MAIN) $P = \frac{P}{A_1} = \begin{cases} 8000 \text{ LBS. WHEN } \frac{L}{R} = 100 \text{ TO } 150 \\ \text{(PAR. I SECTION)} \\ \text{DEC. PERCENTS TO } 8000 \text{ P-83} \\ \text{(PAR. I SECTION)} \end{cases}$ $P_1 = \frac{C P}{A}$ (main) $P_1 = \frac{C R}{A}$ (par.) $R_1 = \frac{0.33 A V^2 L^2}{166 S W}$ (MAIN) $R_1 = \frac{0.33 A V^2 L^2}{166 S W}$ (PAR.) V = 1.66 S N DIA. SPEED & TAKEN	$P + P_1$ SHOULD NOT EXCEED 10 000 LBS. AT DIA. SPEED. A & W TAKEN AT $\frac{3}{4}$ L FROM CROSSHEAD PIN FOR MAIN ROD, AND AT $\frac{1}{2}$ L FOR PAR. ROD. FOR MAIN ROD, A SECTION AS FIG. 3 IS RECOMMENDED, RATHER THAN AS FIG. 1 FOR PAR. ROD, AS FIG. 4 RATHER THAN AS FIG. 3 THICKNESS OF FLANGE SHOULD NOT BE LESS THAN $\frac{3}{4}$". DEPTH OF A RECTANGULAR SECTION PAR. ROD SHOULD BE AT LEAST $\frac{3}{4}$ BETTER $\frac{1}{3}$ OF OUTSIDE DIAMETER OF RIVET OR BACK STUD. FOR STEELS AS A STRUT, L = LENGTH BETWEEN BEARINGS - FOR MEETAL, L = LENGTH - $\frac{1}{3}$ D. FOR MAIN RODS OF L OR I SEC. USE RECTANGULAR SECTION, SAME AS FOR I SECTION

		REMARKS
A = LEAST AREA OF SECTION OF ROD A1 = AREA OF SECTION AT CENTRE OF ROD A2 = AREA PER IN. MAIN OF SECTION B = " " " " " " C = USE QUANTITY 30 000 000 D = LATERAL COMPRESSION STRESS E = VERTICAL " " F = WEIGHT OF ROD IN LBS. (R TO C) G = LENGTH " " " " " " H = " " " SQUARE BEARINGS I = " " " " J = PRESSURE ON PISTON = LBS. K = RAD. OF GYRATION OF SECTION TAKEN L = RADIUS OF CURVATURE OF VERTICAL STRESS M = STROKE IN INCHES N = METTIA STRESS W = MODULUS OF SECTION AT CENTRE OF ROD	$S = \frac{P}{A} = 7000$ LBS. MAX. $P_1 = \frac{0.5 E G^2}{0.125 - 0.3 B}$ $B = \frac{P}{A}$ $P_2 = \frac{0.5 E G^2}{0.125 - \frac{1}{3} B}$ $B = \frac{P}{E A}$ $N = \frac{0.33 L}{W}$	THESE FORMULAE FOR MAIN ROD ONLY. P + P1 SHOULD NOT EXCEED 10 000 LBS. FOR LATERAL COMPRESSION & MAIN ROD VERTICAL AND - FOR VERTICAL COMPRESSION ABOVE THE CENTRE.

		REMARKS
A = LEAST AREA OF SECTION OF ROD A1 = AREA OF SECTION OF ROD TAKEN A2 = AREA PER IN. MAIN OF SECTION OF ROD TAKEN B = " " " " " " " " C = USE QUANTITY 30 000 000 D = COMPRESSION & VERTICAL STRESS E = LATERAL " " F = VERTICAL COMPRESSION STRESS G = METTIA STRESS H = WEIGHT OF ROD IN LBS. (R TO C) I = LENGTH " " " " " " J = " " " SQUARE BEARINGS K = " " " " L = PRESSURE ON PISTON = LBS. M = RAD. OF GYRATION OF SECTION TAKEN N = STROKE IN INCHES O = METTIA STRESS P = MODULUS OF SECTION TAKEN Q = STROKE IN INCHES R = DIAMETER OF CRANK PIN = IN. S = MODULUS OF SECTION TAKEN T = DIAMETER DUE TO CYLINDERS " OF ROD U = COEFFICIENT OF FRICTION	$P = \frac{P}{A}$ (main) $P = \frac{T}{A}$ (rod) $P_1 = 100 P \frac{\pi D^2}{A}$ $P_1 = \frac{0.5 E G^2}{0.125 - 0.3 B}$ (main & rod) $P_2 = \frac{0.5 E G^2}{0.125 - \frac{1}{3} B}$ $B = \frac{P}{A}$ main $B = \frac{T}{A}$ (rod) $N = \frac{0.33 L}{W}$ $P_3 = \frac{0.5 G^2 L}{W}$ main P_3 rod = 0.5 main	P + P1 SHOULD NOT EXCEED 6 000 LBS. T SHALL NOT EXCEED 10 000 LBS. AT PISTON END OF MAIN ROD. T MAY BE 20 000 LBS. THIS.

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FORMULAE FOR CALCULATING STRESSES IN MAIN & PARALLEL RODS

IN USE BY VARIOUS RAILROADS & LOCOMOTIVE WORKS

A = AREA OF SECTION OF ROD TAKEN
B = UNIT COMPRESSION LOAD
C = LATERAL COMPRESSION STRESS
C_v = VERTICAL " "
C_{in} = INERTIA STRESS
D = DIA. OF DRIVERS IN INCHES
E = MOD. OF ELASTICITY = 30 000 000
G = WEIGHT OF ROD BODY IN LBS.
L = LENGTH " " IN INCHES (C TO C)
N = NO. OF PAIRS OF DRIVERS
N_1 = " " " SLIPPED BY ROD
P = DIA. CYLINDERS AT BOILER PRESSURE
R = LOAD TO SLIP
R_1 = RAD. OF GYRATION OF SECTION TAKEN
S = STROKE IN INCHES
W_0 = MODULUS OF SECTION TAKEN
W_1 = WEIGHT ON DRIVERS

$$C = \frac{B}{1 - \frac{.0633\,L^2}{E\,R^2}}$$

$B = \frac{P}{A}$ (MAIN) $B = \frac{R}{A}$ (PAR.)

$$R = \frac{W_1 R N_1}{2.5\,S.N}$$

$$C_1 = \frac{B}{1 - \frac{S^2 L^2}{E\,R^2}}$$

$B = \frac{P}{EA}$ (MAIN) $B = \frac{P N_1}{EAN}$ (PAR.)

$C_{in} = \frac{0.1\,S\,D^2 n}{W_0}$ (MAIN) $C_{in} = \frac{0.1\,S\,D^2 n}{W_0 N}$ (PAR.)

REMARKS

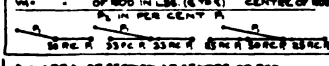
$C_v + C_{in}$ SHOULD NOT EXCEED 12 000 LBS.

A, B & S ARE TAKEN AT 1/2 L FROM CROSSHEAD PIN FOR MAIN ROD, AND AT 7/8 L FOR PAR. ROD.

FOR LATERAL COMPRESSION R IS TAKEN ABOUT VERTICAL AXIS;- FOR VERTICAL COMPRESSION ABOUT HORIZONTAL AXIS.

A = AREA OF SECTION OF ROD TAKEN
B = LOAD PER SQ. INCH OF SECTION AT CENTRE
C = 1/2 DEPTH OF SECTION TAKEN " "
C_c = LATERAL COMPRESSION STRESS
C_v = VERTICAL " "
C_d = DIRECT " "
E = MOD. OF ELASTICITY = 30 000 000
F = LOAD OF CENTRIFUGAL FORCE UNIFORMALLY
G = ACCEL. OF GRAVITY = 32.2 DISTRIBUTED
I = MOM. OF INERTIA OF SECTION TAKEN
L = LENGTH OF ROD IN INCHES (C TO C)
L_1 = " " BODY IN INCHES
W_0 = MODULUS OF SECTION TAKEN
N = CONSTANT = 1/6 FOR SQUARE BEARING
N_1 = " " " PIN " "
P = LAT. STRENGTH PER SQ. INCH TO RESIST
R = PISTON LOAD IN LBS. LATERAL BENDING
R_1 = LOAD ON PAR. ROD IN LBS.
S = RAD. OF GYRATION OF SECTION TAKEN
S_1 = CRANK RAD. IN FEET
S_2 = INERTIA STRESS
V = VELOCITY OF CRANK PIN IN FEET PER SECOND
W = WEIGHT IN LBS. OF A SECTION 1" LONG AT
W_1 = " OF ROD IN LBS. (C TO C) CENTRE OF ROD

A_1 IN PER CENT A



$$C_1 = \frac{B}{1 - \frac{N L^2}{\pi E S^2}}$$ (MAIN)

$\frac{P_1}{P_2}$ SHOULD NOT BE LESS THAN 5 (PAR)

$P = 45\,000 - 0.65\left(\frac{L}{S}\right)^2$

$$C_2 = \frac{B}{1 - \frac{N L^2}{\pi E S^2}}$$ (MAIN)

$C_3 = \frac{P_1}{A}$ (PAR) SHOULD NOT EXCEED 5 000 LBS.

$B = \frac{W V^2 L C}{16\,G\,E\,I}$ (MAIN) $B = \frac{F L}{E I}$ (PAR)

$F = \frac{W V^2}{G.R}$

REMARKS

FOR LATERAL COMPRESSION R IS TAKEN ABOUT VERTICAL AXIS;- FOR VERTICAL COMPRESSION ABOUT HORIZONTAL AXIS.

A = AREA OF SECTION AT CENTRE OF ROD
A_1 = LEAST AREA OF SECTION OF ROD
B = LOAD PER SQ. INCH OF SECTION
C = 1/2 DEPTH OF SECTION
E = MOD. OF ELASTICITY = 30 000 000
F = LATERAL COMPRESSION STRESS
K = VERTICAL " "
K_1 = INERTIA STRESS
L = LENGTH OF ROD IN INCHES (C TO C)
N = CONSTANT = 1/6 FOR SQUARE BEARING
N_1 = " " " PIN " "
P = 1/2 STEAM PRESSURE IN CYL.
R = PULL " " "
S = RAD. OF GYRATION OF SECTION TAKEN
S_1 = CRANK RAD. IN INCHES
S = DIRECT COMPRESSION STRESS
W = LOAD ON ROD IN LBS.

$B = \frac{W}{A_1}$ (MAIN & PAR.)

$$F = \frac{B}{1 - \frac{N L^2}{10\,E S^2}}$$

$B = \frac{P}{A}$ (MAIN) $B = \frac{W}{EA}$ (PAR.)

$$F_1 = \frac{B}{1 - \frac{N L^2}{10\,E S^2}}$$

$B = \frac{P}{A}$ (MAIN) $B = \frac{W}{EA}$ (PAR.)

$F_2 = 0.0583\,R.C\left(\frac{S_1}{S^2}\right)$ (MAIN)

F_3 (PAR.) = 2 F_2 (MAIN)

REMARKS

F + F_2 SHOULD NOT EXCEED 15 000 LBS. FOR MAIN AND 10 000 LBS. FOR PAR. ROD.

F SHOULD NOT EXCEED 10 000 LBS. FOR MAIN AND PAR. RODS.

S SHOULD NOT EXCEED 5 000 LBS. FOR MAIN AND 7 000 LBS. FOR PAR. ROD.

A = LEAST AREA OF SECTION OF ROD
C = ULTIMATE STRENGTH PER SQ. INCH TO
C = INERTIA STRESS RESIST BENDING
D = DIA. OF DRIVERS IN INCHES
F = CENTRIFUGAL FORCE
G = ACCELERATION OF GRAVITY = 32.16
L = LENGTH OF ROD IN INCHES (C TO C)
M = MODULUS OF SECTION
N = NO. PAIRS DRIVERS
N_1 = " " " SLIPPED BY ROD
P = LOAD ON MAIN ROD IN LBS. = AREA CYL. × B.P.
R_1 = " " PAR. " " "
S = RAD. OF GYRATION OF SECTION TAKEN
S_1 = CRANK RAD. IN FEET
S = DIRECT COMPRESSION STRESS
S_2 = STROKE IN INCHES
V = VELOCITY OF CRANK PIN IN FEET PER SEC.
W = WEIGHT OF ROD IN LBS. (C TO C)
W_1 = WEIGHT ON DRIVERS

$S = \frac{P}{A}$ = 5 000 LBS. MAX. (MAIN)

$S = \frac{R}{A}$ = 5 000 LBS. MAX. (PAR)

$$R = \frac{W_1 R N_1}{2.5\,S.N}$$

$C = 45\,000 - 0.65\left(\frac{L}{S}\right)^2$ WHEN $\frac{L}{S} < 150$ (MAIN & PAR.)

C SHOULD BE FROM 2.5 TO 3 P (MAIN)
C SHOULD NOT BE LESS THAN 5R (PAR.)

$C_1 = \frac{F L_1}{E I}$ (MAIN & PAR.)

$F = \frac{W V^2}{F R}$ (MAIN) $F = \frac{W V^2}{16 E}$ (PAR.)

SEE DIAGRAM FOR F

REMARKS

C SHOULD NOT EXCEED 11 000 LBS. FOR PAR. RODS.

RECOMMENDED TO USE AN I SECTION PAR. RODS WITH 1/8" WEB.

OBTAIN F WHEN R = $\frac{1}{8}$

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FORMULAE FOR CALCULATING STRESSES IN MAIN & PARALLEL ROD STUBS
IN USE BY VARIOUS RAILROAD & LOCOMOTIVE WORKS

SECTION A-A

FIBRE STRESS = $\frac{P L}{.1 D^3 t}$ =
- 14 000 LBS.-MAX.-FIG. 1
- 12 000 LBS.-MAX.-FIG. 4
- 10 000 LBS.-MAX.-FIG. 3-5-6-7

P = LOAD ON ROD IN LBS.

SECTION F-F

FIBRE STRESS = $\frac{P}{.8A}$ = 6 000 LBS.-MAX.-FIG. 1-2-3-4-5-6-7

A = MIN. AREA OF SECTION
P = LOAD ON ROD IN LBS.

SHEAR ON BOLTS & KEYS IN STRAP & JAW STUBS

FIBRE STRESS = $\frac{P}{2A}$ = 10 000 LBS.-MAX.

A = AREA OF BOLTS OR KEYS IN SINGLE SHEAR
P = LOAD ON ROD IN LBS.

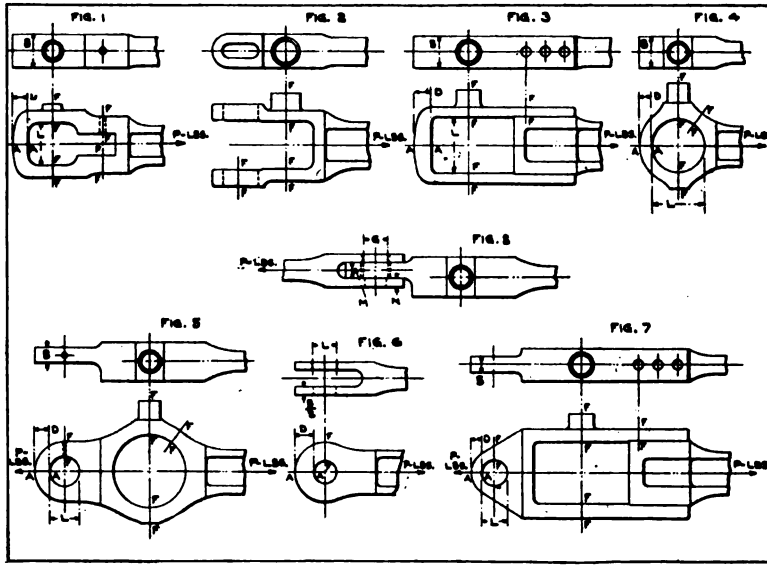
SHEAR ON KNUCKLE PIN

FIBRE STRESS = $\frac{P\left(\frac{H}{2}+\frac{N}{3}\right)}{.098\, d^3}$ = 5 000 LBS.-MAX.-FIG. 8

P = LOAD ON ROD IN LBS.

THIS FORMULA ALLOWS FOR A PIN WHEN LOOSE & BENT.

FIGURES REFERRED TO IN FORMULAE.



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APPENDIX B.

CALCULATION OF STRESSES IN THE BODY OF THE MAIN RODS OF LOCOMOTIVES.

By GAETANO LANZA.

Almost all main rods of locomotives belong in one of the two following classes, viz.:

(A) Those in which the width and the thickness of the flanges, as well as the thickness of the web, are constant throughout, while the depth of the web has a uniform taper.

(B) Those in which the depth and the thickness of the web, as well as the width of the flanges, are constant throughout, while the thickness of the flanges has a uniform taper.

The formulæ for each of these classes will be deduced, an I section being assumed.

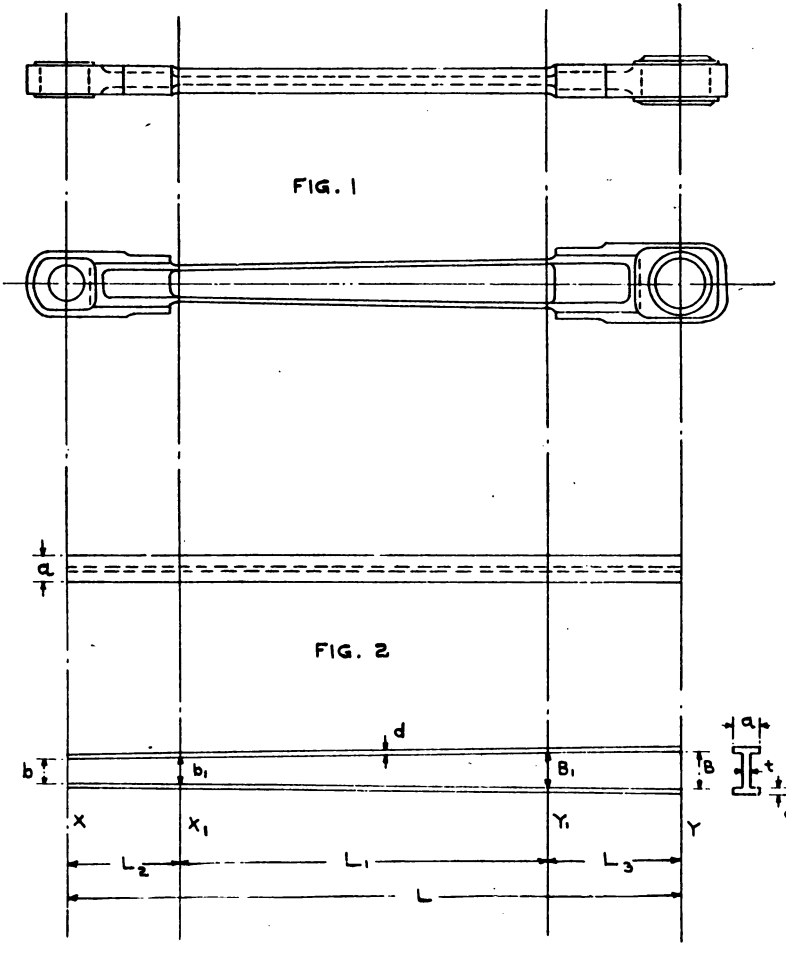
Formulæ for rods of rectangular section and uniform thickness can be obtained from those for class (A), by substituting zero for the width, and for the depth of the flanges.

Formulæ for rods in which the thickness of the web, or the width of the flanges, or both, have a taper, will not be given, but they can be obtained by a method of procedure similar to that employed here.

In deducing the stresses for main rods, the stub ends, including the straps and brasses, will be neglected, since each stub end produces in the body of the rod a positive and a negative bending moment nearly equal in magnitude.

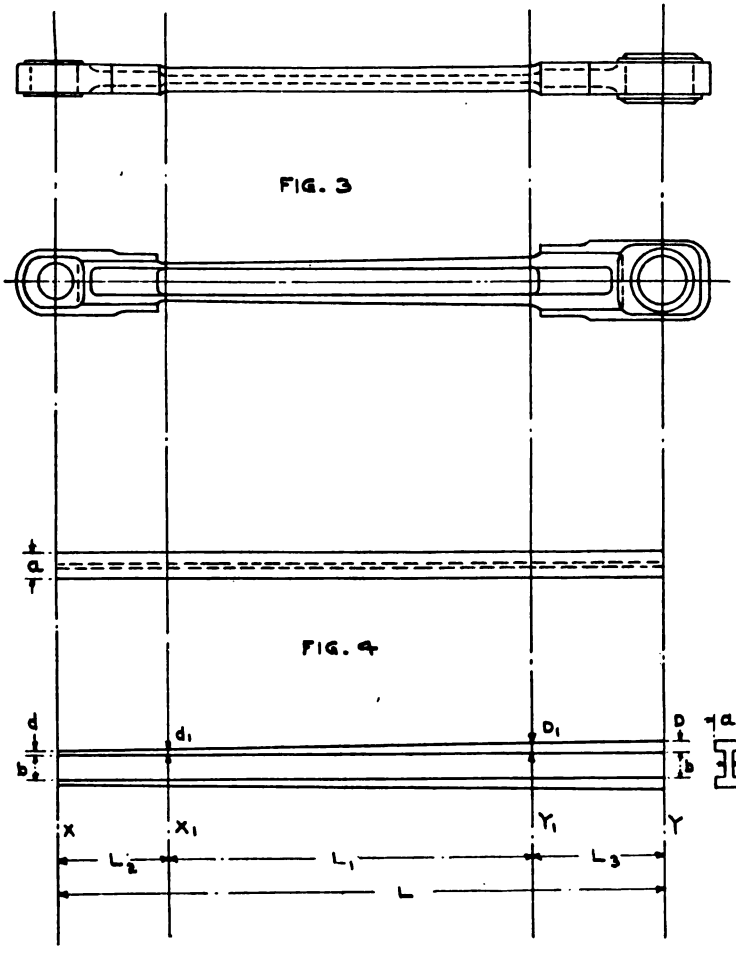
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CLASS A



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CLASS B



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In classes (A) and (B), for the body of the rod will be substituted a rod body of uniform taper throughout, having a length equal to the distance from crank-pin center to crosshead-pin center, the plan of this substituted rod being a rectangle, and its elevation a trapezoid, as shown in Figures 1, 2, 3 and 4.

Fig. 1 shows the plan and elevation of a rod of class (A), and Fig. 2 those of the substituted rod. Fig. 3 shows the plan and elevation of a rod of class (B), and Fig. 4 those of the substituted rod.

In all these figures:

Let X be the crosshead-pin center.
Let Y be the crank-pin center.
Let a = width of flange in inches.
Let t = thickness of web in inches.
Let L = length XY in inches.
Let L_1 = length X_1Y_1 in inches.
Let L_2 = length XX_1 in inches.
Let L_3 = length YY_1 in inches. $\therefore L = L_1 + L_2 + L_3$

In Figures 1 and 2:

Let d = thickness of flange in inches.
Let b_1 = depth of web of rod at X_1 in inches.
Let B_1 = depth of web of rod at Y_1 in inches.
Let b = depth of web of substituted rod at X in inches.
Let B = depth of web of substituted rod at Y in inches.
Then we easily derive from the figures:

$$b = b_1 - \left(\frac{B_1 - b_1}{L_1}\right) L_2 \text{ and } B = B_1 + \left(\frac{B_1 - b_1}{L_1}\right) L_3$$

On the other hand, in Figs. 3 and 4:

Let d_1 = thickness of flange at X_1 in inches.
Let D_1 = thickness of flange at Y_1 in inches.
Let d = thickness of flange at X in inches.
Let D = thickness of flange at Y in inches.
Let b = depth of web of rod and of substituted rod in inches.
Then we easily derive from the figures:

$$d = d_1 - \left(\frac{D_1 - d_1}{L_1}\right) L_2 \text{ and } D = D_1 + \left(\frac{D_1 - d_1}{L_1}\right) L_3$$

We now proceed to work with the substituted, instead of the actual rods. Moreover, the dimensions common to both substituted rods, i. e., that of class (A), and that of class (B) are as follows:

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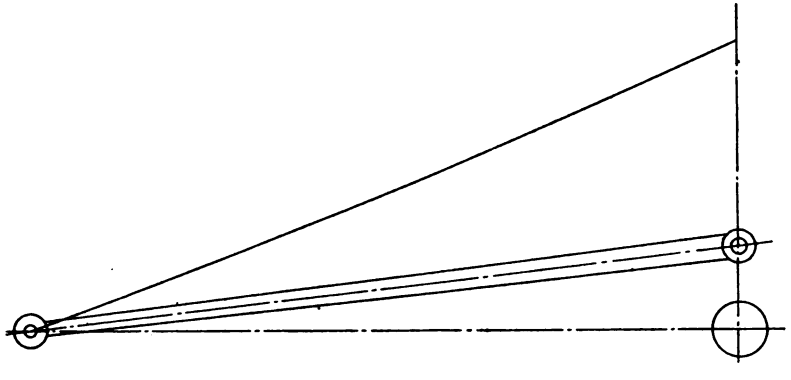
L = length of rod in inches.
a = width of each flange in inches.
t = thickness of web in inches.
Moreover:
Let r = length of crank in inches.
Let w = weight of one cubic inch of steel = 0.2833 lbs. approximately.
Let N = number of revolutions of the crank per minute.
Let g = acceleration due to gravity = (12) (32⅙) = 386 inches per second.
Let α = angular velocity of crank in radians per second

$$\therefore \alpha = \frac{\pi N}{30} = \frac{3.1416N}{30}$$

Let $\theta = \cos^{-1}\sqrt{1-\frac{r^2}{L^2}}$ = angle made by rod with line of dead points, when crank angle = 90°.

Observe that the vertical throw of the rod induces a vertical distributed load upon it, which is greatest at Y, and which decreases gradually to zero at X.

The figure below exhibits this distribution:



We will next proceed to find the expression for the bending moment at any section whose distance from X is e, due to the vertical throw when the crank angle is 90°. Observe that the bending moment due to the horizontal throw is neglected because it is small.

Inasmuch as the formulæ for the two classes of rods will differ, we will first deduce those for Class (A), and subsequently those for Class (B).

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CLASS (A).

Additional discussions are:

d = thickness of each flange in inches.
b = depth of web at X in inches.
B = depth of web at Y in inches.

We then have:

1° Area of cross-section of rod at distance x inches from X

$$= 2ad + t\left(b + \frac{B-b}{L}x\right)$$

2° Let F = vertical reaction at X

3° Then will F cos Θ equal component of this reaction at right angles to the rod.

4° Vertical throw of elementary disc of length dx at distance x from X

$$= \frac{w\,\alpha^2 r}{g}\frac{x}{L}\left\{2ad + t\left(b + \frac{B-b}{L}x\right)\right\}dx$$

5° Component of 4° at right angles to the rod.

$$= \frac{w\,\alpha^2 r}{gL}\left\{2ad + t\left(b + \frac{B-b}{L}x\right)\right\}x\cos\Theta\,dx$$

6° Bending moment at section e inches from X

$$M = (F\cos\Theta)e - \frac{w\,\alpha^2 r}{gL}\cos\Theta\int_0^e\left\{2ad + t\left(b + \frac{B-b}{L}x\right)\right\}x\,(e-x)\,dx$$

$$\therefore M = Fe\cos\Theta - \frac{w\alpha^2 r}{gL}\cos\Theta\left\{(2ad+tb)\frac{ex^2}{2} + t\frac{B-b}{L}e\frac{x^3}{3}\right.$$

$$\left. - (2ad+tb)\frac{x^3}{3} - t\frac{B-b}{L}\frac{x^4}{4}\right\}_0^e \therefore$$

$$M = \cos\Theta\left[Fe - \frac{w\,\alpha^2 r}{gL}\left\{(2ad+tb)\frac{e^3}{3} + t\frac{B-b}{L}\frac{e^4}{12}\right\}\right]$$

Inasmuch as in practical cases cos Θ is very nearly 1 it will be best to put cos Θ = 1, and thus we obtain

$$M = Fe - Ge^3 - He^4$$

where

$$G = \frac{w\,\alpha^2 r}{12gL}\left\{2(2ad+tb)\right\} \text{ and } H = \frac{w\,\alpha^2 r}{12gL}\left(t\frac{B-b}{L}\right)$$

To determine F observe that when e = L the bending moment becomes zero and hence $FL - GL^3 - HL^4 = 0 \therefore F = GL^2 + HL^3$

Hence, to obtain the bending moment at a distance e from X, the crosshead-pin center, we proceed as follows, viz.:

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(a) From the dimensions and speed compute the values of G and H

where $G = \frac{w\,\omega^2 r}{12gL}\left\{ 2(2ad + tb) \right\}$, and $H = \frac{w\,\omega^2 r}{12\,gL}\left\{ t\,\frac{B-b}{L} \right\}$

(b) Compute F from the equation $F = GL^2 + (GL^2 + HL^3)\,HL^3$.

(c) Write out the bending moment at a distance e from X, i. e.:

$$M = Fe - Ge^3 - He^4$$

(d) Let P_1 = total effective pressure on the piston, and hence total force exerted by the piston rod, on the crosshead pin. Resolve P_1 into two components, one of which (P) acts along the rod, and the other at right angles to the guide. Then:

$$P = \frac{P_1}{\cos\theta}$$

(e) Let A = area of section at distance e from X, and let σ_1 = intensity of pressure at this section due to the action of the force P, then

$$\sigma_1 = \frac{P}{A}$$

Moreover we have $A = 2ad + t\left\{ b + \frac{B-b}{L}e \right\}$

(f) Let y = half the depth of the rod, at the same section.

Let I = moment of inertia of the section, about a horizontal axis, in the plane of the section and passing through its center of gravity, and let σ^2 = outside fiber stress at the section due to the throw.

Then we have:

$$\sigma_2 = \frac{My}{I}$$

Moreover $y = \frac{1}{2}\left\{ b + \frac{B-b}{L}e \right\} + d$

and if we let $b_2 = b + \frac{B-b}{L}e$ = depth of web at the section we have

$$I = \frac{1}{12}\left\{ a\,(2d + b_2)^3 - ab_2^3 + tb_2^3 \right\}$$

(g) Then if σ denotes the total outside fiber stress per square inch in the rod at this section we have

$$\sigma = \sigma_1 + \sigma_2$$

(h) On a piece of cross-section paper plot a curve having for abscissae distances along the rod measured from X, i. e., values of e, and for ordinates the corresponding values of σ. It will only be necessary to calculate and plot four values of σ, two corresponding to values of e less

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than ½ L, and two corresponding to values of e greater than ½ L, and all within six inches of the middle of the rod, and then a curve can be drawn through the four points and from this curve can be determined the greatest outside fiber stress in the rod.

In carrying out the above stated calculations, we have to use some value of N, the number of revolutions of the driver per minute. This value should be as large as will ever be attained in practice, whether by design or by accident. I have been accustomed to use $N = 375$.

As to the value to be used for P_1 there may be room for considerable difference of opinion. I have generally used the product of the area of the piston by one-half the boiler pressure per square inch.

Class (B).

Additional dimensions:

d = thickness of each flange at X in inches.

D = thickness of each flange at Y in inches.

b = depth of web throughout in inches.

We then have:

1° Area of cross-section of rod at distance x inches from X

$$= 2a(d + \frac{D-d}{L}x) + tb = (2ad + tb) + 2a\frac{D-d}{L}x$$

2° Let F = vertical reaction at X

3° Then will F cos θ = component of this reaction at right angles to the rod.

4° Vertical throw of elementary disc of length dx at distance x from X

$$= \frac{w\,\omega^2 r}{g}\frac{x}{L}\left\{(2ad + tb) + 2a\frac{D-d}{L}x\right\}dx$$

5° Component of 4° at right angles to the rod

$$= \frac{w\,\omega^2 r}{gL}\left\{(2ad + tb) + 2a\frac{D-d}{L}x\right\}x\cos\theta\,dx$$

6° Bending moment at section e inches from X

$$M = (F\cos\theta)e - \frac{w\,\omega^2 r}{gL}\cos\theta\int_0^e\left\{(2ad + tb) + 2a\frac{D-d}{L}x\right\}x(e-x)dx$$

$$\therefore M = Fe\cos\theta - \frac{w\,\omega^2 r}{gL}\cos\theta\left\{(2ad + tb)\frac{ex^2}{2} + 2a\frac{D-d}{L}\frac{ex^3}{3}\right.$$

$$\left. - (2ad + tb)\frac{x^3}{3} - 2a\frac{D-d}{L}\frac{x^4}{4}\right\}_0^e$$

$$\therefore M = \cos\theta\left[Fe - \frac{w\,\omega^2 r}{gL}\left\{(2ad + tb)\frac{e^3}{3} + 2a\frac{D-d}{L}\frac{e^4}{12}\right\}\right]$$

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Inasmuch as in practical cases cos Θ is nearly 1, it will be best to put cos Θ = 1, and thus we obtain:

$$M = Fe - Ge^3 - He^4$$

where $G = \frac{w\,\alpha^2 r}{12gL}\left\{2(2ad + tb)\right\}$ and $H = \frac{w\,\alpha^2 r}{12gL}\left(2a\,\frac{D-d}{L}\right)$

To determine F observe that when e = L, the bending moment becomes zero and hence $FL - GL^3 - HL^4 = O$ ∴

$$F = GL^2 + HL^3$$

Hence, to obtain the bending moment at a distance e from X, the crosshead-pin center, we proceed as follows, viz.:

(a) From the dimensions and speed compute the values of G and H

where $G = \frac{w\,\alpha^2 r}{12\,gL}\left\{2(2ad + tb)\right\}$ and $H = \frac{w\,\alpha^2 r}{12gL}\left\{2a\,\frac{D-d}{L}\right\}$

(b) Compute F from the equation $F = GL^2 + HL^3$

(c) Write out the bending moment at a distance e from X, i. e.,

$$M = Fe - Ge^3 - He^4$$

(d) Let P_1 = total effective pressure on piston, and hence total force exerted by the piston rod on the crosshead pin.

Resolve P_1 into two components, one of which (P) acts along the rod, and the other at right angles to the guide. Then

$$P = \frac{P_1}{\cos\Theta}$$

(e) Let A = area of section at distance e from X and let σ_1 = intensity of pressure at this section due to the action of the force P. Then

$$\sigma_1 = \frac{P}{A}$$

Moreover, we have:

$$A = (2ad + tb) + 2a\,\frac{D-d}{L}\,e$$

(f) Let y = half the depth of the rod, at the same section, and let I = moment of inertia of the section, about a horizontal axis, in the plane of the section, and passing through its center of gravity.

Let σ_2 = outside fiber stress at the section due to the throw.

Then we have:

$$\sigma_2 = \frac{My}{I}$$

Moreover, $y = \frac{1}{2}b + \left(d + \frac{D-d}{L}\,e\right)$

and if we let $d_2 = d + \frac{D-d}{L}\,e$ = depth of one flange at the section, we have:

$$I = \frac{1}{12}\left\{a(2d_2 + b)^3 - ab^3 + tb^3\right\}$$

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(g) Then if δ denotes the total outside fiber stress per square inch in the rod at this section, we have

$$\delta = \delta_1 + \delta_2$$

(h) The remainder of the method of procedure is identical with that in the case of Class (A) and will not be repeated here.

CALCULATION OF STRESSES IN SIDE RODS OF LOCOMOTIVES WHEN THERE IS NO KNUCKLE-JOINT.

Let W = weight of rod minus weight of stub ends in pounds.

Let r = length of crank in inches.

Let L = length of rod in inches, center to center of crank pin.

Let g = acceleration due to gravity = (12) (32⅛) = 386 inches per second.

Let A = area of section in square inches.

Let I = moment of inertia of section of rod about a horizontal axis lying in the plane of the section and passing through the center of gravity of the section, units being inches.

Let y = distance from above stated axis to top or bottom of section = one-half entire depth of section in inches.

Let N = number of revolutions of crank pin minute.

Let α = angular velocity of cranks in radians per second, hence

$$= \frac{2\pi N}{60} = \frac{\pi N}{30}$$

Let F = total throw of rod in pounds.

Let d = deflection at center of rod due to centrifugal force in inches.

Let M_1 = bending moment at middle section due to the centrifugal force only, in inch pounds.

Let P = total force transmitted through the rod.

Let M_2 = Pd = bending moment caused by P in consequence of deflection d, in inch pounds.

Let $M = M_1 + M_2$ = total bending moment at middle section.

Let δ_1 = outside fiber stress in pounds per square inch due to M_1.

Let δ_2 = outside fiber stress in pounds per square inch due to bending moment M_2.

Let $\delta_3 = \frac{P}{A}$ = stress in pounds per square inch due to P.

Let $\delta = \delta_1 + \delta_2 + \delta_3$ = greatest stress in rod in pounds per square inch.

Let E = modulus of elasticity of material of rod.

We then have that

$$F = \frac{w \alpha^2 r}{g}$$

The centrifugal force may be considered with a sufficient degree of

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approximation, as a uniformly distributed, transverse load on the rod. Hence,

$$M_1 = \frac{FL}{8} = \frac{1}{8}\frac{w\,\omega^2 rL}{g}$$

$$\delta_1 = \frac{M_1 y}{I} = \frac{1}{8}\frac{w\,\omega^2 rL}{g}\frac{y}{I}$$

$$d = \frac{5}{384}\frac{FL^3}{EI} = \frac{5}{3072}\frac{w\,\omega^2 rL^3}{g\,E\,I}$$

We also have

$$\delta_2 = \frac{Pd\,y}{I}$$

$$\delta_3 = \frac{P}{A}$$

Hence $\delta = \delta_1 + \delta_2 + \delta_3 = \frac{M_1 y}{I} + \frac{M_2 y}{I} + \frac{P}{A}$

As to the value to be used for N, it should be the same as that used in the case of the main rod. If N = 375 is used in one case it should also be used in the other.

As to the value to be used for P, there is room for considerable difference of opinion. I would suggest in the case of an ordinary eight-wheel locomotive:

$$P = \frac{1}{2}\left(\frac{\pi d_1^2}{4}\right) p$$

where d_1 = diameter of piston in square inches.
and p = one-half the boiler pressure in pounds per square inch.

THE PRESIDENT: Gentlemen you have heard the report of the Committee on Main and Side Rods.

Before opening the discussion, I understand that the oldest living Ex-President of this Association is in the city — Reuben Wells. Is he in the room? [No response.] The next two oldest Ex-Presidents are here — Mr. Garstang and Mr. Mackenzie, and I would ask the youngest Ex-President, Mr. Wildin, to escort them to the platform.

MR. WILDIN: Mr. Mackenzie has gone out. At least, I saw him go out a moment or two ago. Shall I go out and look for him?

THE PRESIDENT: He is here now. He is sitting right ahead of you, and there is Mr. Garstang. Your duty is to bring them forward.

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G. W. WILDIN: I will bring them.

[Mr. Wildin then escorted Mr. Garstang to the front.]

THE PRESIDENT: Gentlemen, this is Mr. Garstsang, one of your oldest Ex-Presidents — 1894.

While the Marshal is completing his duty and finding Mr. Mackenzie we will proceed with the discussion of the report.

MR. SELEY, can you give us any light on the subject?

MR. SELEY: I do not believe I can, as I have not seen a copy of the report until this moment. The committee in its modesty did not put on the date at which the report was printed. So I do not know whether it is up to the Secretary or to the committee. I feel, however, from what I have been able to hear and to see that this is a very valuable addition to the literature of the subject —

[At this point Mr. Mackenzie was escorted to the platform.]

G. W. WILDIN: Mr. President, is my duty done now?

THE PRESIDENT: Not until you get Mr. Reuben Wells.

Gentlemen, I present Mr. Mackenzie, who was President of the Association in 1890.

Mr. Seley, you may continue now.

MR. SELEY: As I was saying, I think this is a very valuable addition to the records of the Association, and it will assist us in calculating and checking rods, particularly the shortened form, which will be of very great assistance to us for that purpose.

The value of this Association, to a very considerable extent at least, is in the preparation of works of this kind, which go out with the authority that is back of the signatures of the men who have prepared them.

THE PRESIDENT: Has any one else anything to say on this subject? This is an important subject. The paper is well gotten up, and we would be very glad to have the views of the members.

MR. GAINES: I wish to reiterate somewhat what Mr. Seley has said in regard to the value of the paper and in regard to the value of papers of this kind to the Association. I think it is extremely valuable to have formulæ of this kind worked out by

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a responsible committee and on record in the Proceedings of this Association.

I have not had time to go over the paper and digest it as thoroughly as I should like to, but there is one little item brought out that appeals to me, and that is, where the rods are offset and the additional allowance that must be made. I want to say that that is a very important little item. I found years ago on some engines we had on one road where the rods had been considerably offset to keep the cylinder spread down, that we were breaking these rods continuously, and yet the sections of them were as large, or even larger in proportion, to engines of equivalent power that had straight rods that were giving us no trouble, and it took considerable figuring and feeling around before we finally decided that the offset was at the bottom of the thing. In the next lot of engines we ordered of that type, we spread the cylinders wider and got the rods straightened out and with the same section of rod we finally got rid of all trouble of that kind. That has taught us it is an exceedingly important thing, if you have to offset rods on consolidation locomotives, where it is principally done, that you must have considerable strength in the rod to compensate for the offset.

THE PRESIDENT: Mr. Rink, can you give us some information on this subject?

MR. RINK: Mr. Chairman, we have experienced a little trouble with certain side rods due to the fact that they were designed with two high a working stress. I believe that formulæ of this kind, as given in the report of the committee, are very essential so that we can arrive at standard practices. I found that these rods to which I refer had stresses exceeding 15,000 and 16,000 pounds per square inch, and when brought down to 12,000 pounds, they gave excellent service.

Regarding the middle side rod connection shown on page 16, I believe the fork end of the connection should be built on to the strap, and have either the back rod or the forward rod made with the tongue, as I believe it will facilitate the repairs. We have experienced considerable trouble in the breakage of fork-end rods, principally on 10-wheel engines, and we do not seem

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to have been able to get over this difficulty as yet. We have got around the repair part of it, by simply welding another portion of the fork, that is, one of the half portions of the fork, by means of thermit welding and it makes a very excellent job.

I believe one of the important features in connecting rods of that type is to look after the knuckle pins and see that they are always kept up properly. We have found it necessary to apply single nuts and allow the pin to project beyond the nut about one-eighth of an inch and then rivet over the pin there. We also apply a washer about one-eighth inch thick between the side of the rod and the under side of the nut, and we find that also helps to keep up that particular connection in good shape.

I am glad to be in possession of this report of the committee, as I have been looking for some data on this subject. There are considerable data published covering rod design for stationary practice, but that does not hold good in locomotive practice. I have not had time to go through the paper in detail, but I feel sure we all appreciate a paper of this kind.

MR. HAIG: I desire to get some information and at the same time will ask one or two questions, which will tend to bring out a little further discussion, as the discussion does not seem to be very active at the present time.

As a usual practice the web portion of the I-section rod is made of the same thickness throughout the length. A number of rods break just about at the end of the web, where the fluted portion begins. I was told some time ago of an improvement being made by tapering the web portion near the end rather than making the web the same thickness throughout. I would like to ask if any one here has actually put this in practice, and if it has been found that such a section overcomes the breaking to which I referred.

MR. GAINES: I know that in practice, especially on main rods, where the front end trouble is caused by a narrowing of the metal, and this is overcome by a long tapering rod — I have known of several designs of engines where they started out with a half-inch web at the back end and run the web up as heavy as an inch at the front end of the main rod, and it has overcome that trouble.

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MR. RINK: In designing these side rods we increase the amount of metal in the corner of the web, making the radius about 12 to 15 inches, so that the web would increase from five-eighths of an inch to almost 2 inches, up close to the butt. We find that that saves the rod considerably, its effect being to decrease the tendency toward side buckling.

THE PRESIDENT: We will be glad to hear from some other of the members on this subject.

MR. FORSYTH: I think it can be safely said that the main rods and side rods on American locomotives are the largest and heaviest, proportioned to cylinder thrust, that are used by any country in the world, and I have wondered what the reason is. Is it due to the use of low fiber stress in the steel, or is it due to a large factor of safety, to allow for defective material? I should think we have reached the point in steel manufacture where, in buying billets for rods, we could depend on uniform quality, and it would not be necessary to allow for defects in material as part of the factor of safety.

Then we have high-strength steel, 80,000 pounds, which should allow an elastic limit of over 40,000 pounds, and taking that, for the working stress of 20,000 pounds, I should think that we could get steel which ought to have a practical working stress sufficient to meet the requirements. A gentleman near me says that he finds that 15,000 is too high. If you can not use a stress of 15,000 pounds in high carbon steel for locomotive rods, it must be because there is either an allowance for defective material or very rough work on the part of the engineer.

W. F. KIESEL: Referring to what Mr. Forsyth remarks, he possibly lost sight of the fact that the stresses in rods reverse, necessitating the use of low unit stress. For instance, taking a steel of 80,000 pounds ultimate tensile strength and 40,000 pounds elastic limit, it would not be proper to use a stress higher than the one specified here, amounting to about 13,000 pounds per square inch, as this stress acts alternately as tension and compression. That is the reason why engineers keep the stresses low. Furthermore it would be dangerous to life if a side rod should break which would be apt to cause a bad wreck involving

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the whole train. Hence the stresses ought to be kept rather low. There is one thing that the committee would like to emphasize, namely, the request made that members shall send in criticisms before February 1, 1912. We realize that they have not had very much time to go over this paper, but we hope that they will go over it rather carefully and give us the benefit of any suggestions or criticisms that may occur to them.

THE PRESIDENT: Mr. McRae, can we hear from you on this subject?

MR. J. A. MCRAE (Mich. Central R. R.): It is the practice on some roads to put a fillet on the corners to prevent cracks starting. I think that is good practice, and I do not recall that it was mentioned in the report.

MR. BENTLEY: I think this is one of the most valuable papers that has ever come before the convention. It will help many of us in the matter of calculating stresses and strains on rods.

Our own road is similarly situated to many other roads in that we are having a whole lot of breakage of main rods and side rods. In making some etchings of side rods that broke immediately after being delivered to us by the builders we found the material was very poor and our Engineer of Tests said: "You go to work and get a billet and hammer it up and close the grain, and then you mill out the best part of it and therefore you reduce the strength of your rod." He has advocated that we go back to the rectangular rod.

It seems to me that even with the large factor of safety that is allowed it is not enough when you get poor material. I am sorry to say that some rods we have been getting have been very poor indeed.

We have had steel rods come with engines that have broken and we have had to replace them with iron of our own manufacture of a very much lower tensile strength and they have given us good service where the I-section steel rods furnished by the manufacturer did not stand up. I would like to ask if any of the members here have gone from the I-section rod to the

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rectangular rod for the purpose of getting away from the difficulty I have mentioned?

MR. GAINES: In answer to Mr. Bentley's inquiry I would say that I am developing a scheme to remedy that difficulty. We have a forging press using a very slow action hydraulic machine, and we are endeavoring to make it work so that we can run the metal right through and avoid the trouble Mr. Bentley refers to; it is a fact that the best part of the metal is now being removed by milling it out.

With regard to what Mr. Forsyth had to say relative to low stresses, I would ask him if he has two stresses considered. First, take a beam that is a long column. There you have to consider the stress in connection with that long column. Then that same long column in addition to the loading at the end of the beam on the side rods, calculated at the center, and on the main rod about .6 of the crossed end, the centrifugal loading. Now, you have to take those into consideration, and you will find that the unit stress is not very light, because if you add up the long stress of the long column action and the inertia action you get a stress very much higher in reality.

MR. BENTLEY: I am glad to know that Mr. Gaines is going to do something that has been recommended. I presume it will be practically impossible to rough-roll, but in the tests that our Engineer of Tests has made that difficulty will be very much overcome.

MR. WILDIN: Mr. President, I present Mr. Reuben Wells.

THE PRESIDENT: Mr. Wells, we would be very glad to have you come forward and take a seat on the platform. It is a pleasure to have with us this morning the oldest Ex-President of the Association — Mr. Reuben Wells, who was President in 1882-84. [Applause.]

MR. FORSYTH: In reply to Mr. Gaines I would say that the forces he mentions must act in other countries as they do here, and foreign engineers must use a higher unit stress to arrive at the small sections that are used almost all over the world in contrast with the heavy sections used in America.

THE PRESIDENT: Mr. Wildin, I think you are entitled to a

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seat on the platform, and I want to thank you on behalf of the convention for the way in which you have performed your labors as Marshal.

Is Mr. Dalton, of the American Locomotive Works, present? [No response.] Is Mr. Blunt, of the American Locomotive Works, here? Mr. Blunt, we will be very glad to hear from you as to your practice and your views on the best construction of side rods.

MR. J. G. BLUNT (American Locomotive Co.): We have had a great deal of trouble with getting uniform material for rods. On several billets during the past year a pipe has run entirely through the rod. I remember in one instance the pipe ran up the end of the rod and opened up a cross fracture about 3-16 inch wide. In some cases we are unable to see those fractures, although we give our rods very close inspection.

We have been using heat treatment on rods to quite an extent, and we find that we get fully as good or better results by omitting the heat treatment in many cases.

It has been the usual practice to follow out the method of rounding off the corners of rods to prevent fractures growing.

MR. MCRAE: In reference to Mr. Bentley's remarks about I section rods, I would say that we have discarded I section rods for all low-speed engines like freight service. We smooth forge the rectangular rods. We started the smooth forging for another purpose than getting dense metal, and get what benefit there is on account of not cutting out the good metal that Mr. Bentley referred to. I might say that we get very good service from rectangular forged rods as compared with I section rods.

THE PRESIDENT: Has not the Erie got a lot of forged fluted rods?

MR. HAYES: No; I think it was the Central Vermont that had those rods.

THE PRESIDENT: Is there anybody here from the Central Vermont Road? The question of forged fluted rods I might say is an old one. This was the practice with the light engine when I went to the Central Vermont Road in 1892, and I know that a large number of their engines were equipped with fluted rods

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forged without any machining other than the bush centers, and, if I remember correctly, these rods gave excellent service; but whether the same results would carry out with the heavier type of engines is a question, as the present day rod is so much heavier and larger that it makes a very heavy forging.

I think the practice of putting rods as nearly in vertical line as possible is an absolute necessity. We have a large number of engines where the offset in the rods is excessive, and it has been our experience that the most of the trouble is with these rods. I think the rods should be designed with the idea in view of getting them more in a straight line to do away as far as possible with offsets, and thus prevent eccentric loads. It is, of course, an impossibility to do this entirely with the consolidation engines, but it can be accomplished to a great extent. We have redesigned a great many of our rods and we have been getting better results.

Mr. McBain, can you give us the benefit of your experience?

MR. MACBAIN (L. S. & M. S. Ry.): We had considerable experience on the New York Central when I was there with the various types, fluted and otherwise, and we about came to the conclusion that for all slow speed engines the rectangular section is by far the best proposition. In the first place we were trying to smooth forge them and leave the outer shell, excepting on the ends where machining must be done, just as it came from under the hammer. The results were very satisfactory.

We used to have a great deal of breakage, especially on the consolidation engine, with the I-section, and we started in five or six years ago on the Michigan Central Railroad and substituted a rectangular section. That has given no trouble whatever, and we have had satisfactory results.

We have found that it is better where possible to have the rod straight and cut out all the offsets that we can. Many breaks have occurred at the offset which we believe would not have occurred if the rod had been straight.

On the whole I think that the experience we had on the New York Central Lines, not only on the low-speed engines but on some of the high-speed engines, which Mr. MacRae knows more about than I do, justifies the Michigan Central in doing what

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they are doing, in putting on rectangular section rods on some of their high-speed passenger engines. I think on the whole it is a very much better proposition.

THE PRESIDENT: Is there a representative here from the Baldwin Locomotive Works [No response.] Is Mr. Knight, of St. Louis here? [No response.] Are there any other members who have anything to say on this subject?

MR. PATTERSON (Grand Trunk): We have had considerable experience in forging fluted side rods for light locomotive power. We did it altogether on the Grand Trunk Ry. at Stratford shops, but since we adopted the heavy power we have been rough-forging and fluting our side rods by machinery. We had considerable trouble with the fluted side rods breaking and we substituted the rectangular rod. Probably if we had forged our heavy fluted rods in the same way as we did for the smaller power we would not have had as much trouble. Of course, rods will break, no matter whether rectangular or fluted, if they are not kept up, but I believe on the whole that the rectangular rod will give better service and have less failures than the fluted rod.

MR. CROMWELL: We have used rectangular rods on consolidated freight engines and the I-section rods on the passenger engines. I think this practice has developed in recent years since we have increased the wheel base of the locomotive. The larger in-play that we get in the drivers on a consolidated locomotive I think contributes toward the failure of the rod. We not only have failure through the I of the rod where we use the bushing, but we have it in the jaws, and we have trouble in keeping the wrist-pins tight. It occurs to me that what we want is a rod that will spring laterally as well as vertically — a kind of universal joint. That would keep the in-play between the drivers and the driving box down and would help in increased mileage. I think another method would be to give plenty of lateral play in the crank pin. We tried that to some extent. We had trouble in keeping the collars on the crank pin. It occurs to me that that would be a field for some fruitful investigation. That is, I mean, the lateral play between the bushes and the crank pin, and the amount that we can safely use without pushing off the crank-pin collar.

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We have in service one locomotive with a universal connected tie rod, and we are looking forward to some result in that direction, but I can not tell you anything about it at present.

THE PRESIDENT: I was going to ask you in that connection if you could not give us some light on the universal rod connection.

MR. CROMWELL: I can not at present, because it has not been in service long enough yet.

MR. WILDIN: I think that a great deal of the trouble experienced with side rods is due to the slipshod manner in which they are designed. Just prior to my connection with the New Haven Road they ordered 12 Atlantic type engines from the builders. Three of these engines stripped themselves while hauling our fast limited trains inside of three months. The rods were of the I-section type. We took all of the engines out of service and equipped them with an I-section rod of proper design. They have now been running for about four years without any trouble whatever. I think it is safe to say that at least nine-tenths of this trouble is due to poor designing and not so much to the particular section.

THE PRESIDENT: Are there any further remarks on this subject?

MR. CHAMBERS: I would like to say that we are annealing all of our main rods and side rods that have been in service five years or more, and we find that it has very much reduced the crystallization effect. I would like to know whether any of the other members here have followed a similar practice?

THE PRESIDENT: We anneal all of our rods. We not only do it for the usual results of annealing, but we put them in fire to detect cracks. We think this is an additional safeguard. We know that we have found cracked rods that might not have been otherwise found. However, I am not prepared to say to just what extent annealing has benefited us.

MR. CHAMBERS: How often do you do that, Mr. President?

THE PRESIDENT: Every time an engine comes into the shop for general repairs regardless of the age of the engine, and particularly for rods that have been painted or previously repaired.

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Of course, you understand we would not do this with a new engine.

MR. CROMWELL: I would say that we have found considerable trouble in keeping the main pin side rod bushing tight, because the diameter of hole in the eye is much larger than the body of the rods, and extends outside of same, and allows the eye to spring out of shape and the bushing to loosen. Recently we have tapered the middle section of the side rod in the vertical direction, toward the main pin, thereby backing up the eye to a greater extent, and preventing its distortion, which we think will overcome the trouble, but we can not say much at this time of the success of this method of preventing the distortion of the eye, as it has been in service only a short time.

If you have loose bushings and pins in the knuckles of the rods, it causes hammer blows, and sets up stresses which it is difficult to calculate, and furthermore, I believe the failure of the rods is due to the stresses set up by the larger end play with which the locomotives are run nowadays before they are shopped, thereby springing the rods out of alignment transversely of the locomotive.

Some means of providing for lateral as well as vertical movement in the knuckle-joint of the rod is something that is desirable, because of the lateral distortion produced by the longer wheel base of modern locomotives and the greater end play used.

MR. CHAMBERS: My solution for that difficulty is a split brass rod-link connection. We have engines of different types, both with the solid bushing and the split brass, and I feel free to say that our troubles are much less with the split brass than with the bushings.

MR. BENTLEY: For the information of the members, I will say that instead of putting a rod in the fire to find out if there are any cracks in it, we whitewash it, we put on it a very heavy coat of whitewash, and then let the rod stand for a day or so, and if there are any cracks in it they soon show up. It is a simple thing, and may be of interest to the members to know this.

MR. ANGUS SINCLAIR: I may mention a practice I have seen followed in the European shops to a great extent, that is, when

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the rods are taken off they are thoroughly wiped, so that any oil starting can be seen readily; the rods are then put on trestles, each end of the rod resting on a trestle, and the rod is then struck heavily in the middle with a wooden mallet, and that seems to start any oil out of any crack that may happen to be in the rod unperceived. I think it is regarded as very good practice, and probably that prevents a great many failures of rods.

THE PRESIDENT: Are there any other members who desire to speak on this subject? If not, we will ask Mr. Kiesel to close the discussion on the paper.

MR. KIESEL: I do not think there is anything more to say except again to ask the various members of the association to let us hear from them before February 12, after they have had a chance to examine the report over more thoroughly, compare it with their own practice, and advise us whether they consider the stresses indicated as checking stresses too high.

THE PRESIDENT: We will now take up the next committee report on "Formulæ for Diameter of Piston Rods and Size of Crossheads for Locomotives," of which committee Mr. J. A. McRae is the chairman.

MR. MCRAE presented the following report:

REPORT OF COMMITTEE ON FORMULÆ FOR DIAMETER OF PISTON RODS, AND SIZE OF CROSSHEADS FOR LOCOMOTIVES.

To the Members:

Your committee appointed to present formulæ for the proper diameter of piston rods and sizes of crossheads have obtained data from a number of the largest railroads and from locomotive builders. We find several different formulæ and designs in use which are giving satisfactory results, therefore representative groups of the data obtained are presented instead of recommending only one set of formulæ for each part.

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GROUP I.

PISTON RODS.

Let

P equal area of piston × boiler pressure.

S equal fiber stress.

A equal least area of piston rod through key-way.

Allowable working fiber stress in tension, 9,500 pounds per square inch for steel.

Then

$$(1)\quad A = \frac{P}{S}$$

Piston rods to have enlarged fit in piston and in crosshead; ends to be approximately ¼ inch greater in diameter than body of rod.

CROSSHEAD KEY.

Allowable working fiber stress, 17,000 pounds per square inch for spring steel.

The diameter of body of piston rods, based on 9,500 pounds fiber stress in tension at least area through key-way, with nominal diameter of cylinder and full boiler pressure for simple engines, are shown in Table I. The sizes vary by even ¼ inches.

TABLE I.

DIAMETER OF BODY FOR PISTON RODS.

Cylinder Diameter.	Boiler Pressure.				
	180	190	200	210	220
16″	2¼″	2¼″	3 ″		
16½″—17″	2¼″	3 ″	3 ″		
17½″—18″	3¼″	3¼″	3¼″	3¼″	
18½″—19″	3¼″	3¼″	3¼″	3½″	
19½″—20″	3½″	3½″	3½″	3½″	
20½″—21″	3¾″	3¾″	3¾″	3¾″	3¾″
21½″—22″	3¾″	3¾″	4 ″	4 ″	4 ″
22½″ ..	4 ″	4 ″	4 ″	4 ″	4 ″
—23″	4 ″	4 ″	4 ″	4 ″	4¼″
23½″—24″	4¼″	4¼″	4¼″	4¼″	4¼″
24½″—25″	4¼″	4¼″	4¼″	4¼″	4½″
25½″	4½″	4½″	4½″	4½″	.....

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The dimensions of piston-rod end for piston rods with body diameter as shown in Table I are given in Table II and Fig. 1.

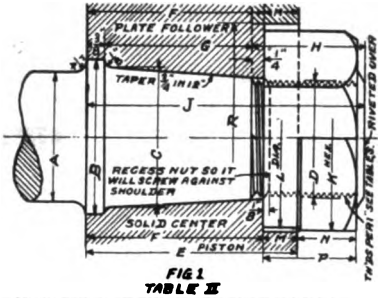


FIG 1

TABLE II

DIMENSIONS FOR PISTON END OF PISTON ROD.

A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S
2 3/4"	3 1/4"	3"	2 1/2"	4 1/2"	3 3/4"	3 1/8"	2 3/8"	5 7/8"	3 7/8"	3 3/4"	3/4"	1 1/4"	2"	4 3/4"	8
3"	3 1/2"	3 1/4"	2 3/4"	4 1/2"	3 3/4"	3 1/8"	2 3/8"	5 7/8"	4 1/4"	4 1/8"	3/4"	1 1/4"	2"	5 1/4"	8
3 1/4"	3 3/4"	3 1/2"	3"	5 1/2"	4 3/4"	4 1/8"	2 3/8"	6 7/8"	4 5/8"	4 1/2"	3/4"	1 1/4"	2"	5 3/4"	8
3 1/2"	4"	3 3/4"	3 1/4"	5 1/2"	4 1/2"	3 7/8"	2 3/8"	7 1/8"	5"	4 7/8"	1"	1 1/2"	2 1/2"	6"	6
3 1/2"	4"	3 3/4"	3 1/4"	6 1/2"	5 1/2"	4 7/8"	2 3/8"	8 1/8"	5"	4 7/8"	1"	1 1/2"	2 1/2"	6"	6
3 3/4"	4 1/4"	4"	3 1/2"	6 1/2"	5 1/2"	4 7/8"	2 3/8"	8 1/8"	5 1/4"	5 1/8"	1"	1 1/2"	2 1/2"	6 1/2"	6
4"	4 1/2"	4 1/4"	3 3/4"	6 1/2"	5 1/2"	4 7/8"	2 3/8"	8 1/8"	5 1/2"	5 1/8"	1"	1 1/2"	2 1/2"	6 3/8"	6
4"	4 1/2"	4 1/4"	3 3/4"	7"	6"	5 3/8"	2 3/8"	8 5/8"	5 3/4"	5 1/8"	1"	1 1/2"	2 1/2"	6 3/8"	6
4 1/4"	4 3/4"	4 1/2"	4"	7"	6"	5 3/8"	3 3/8"	9 1/8"	6 1/8"	6"	1"	2"	3"	7 1/4"	6
4 1/2"	5"	4 3/4"	4 1/4"	7"	6"	5 3/8"	3 3/8"	9 1/8"	6 1/2"	6 3/8"	1"	2"	3"	7 3/4"	6

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The dimensions of the crosshead end are given in Table III and Fig. 11.

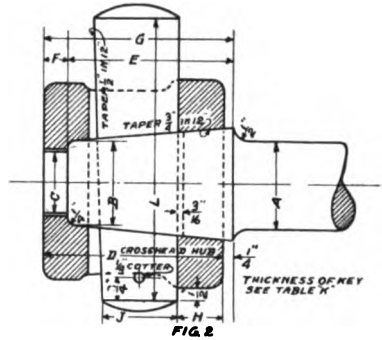


FIG. 2

TABLE III

DIMENSIONS FOR CROSSHEAD END OF PISTON ROD.

A	B	C	D	E	F	G	H	J	K	L
2 3/4"	2 5/8"	1 15/16"	5 3/4"	5 1/4"	3/4"	6"	1 1/2"	2 3/8"	5/8"	9"
3"	2 7/8"	1 15/16"	5 3/4"	5 1/4"	3/4"	6"	1 1/2"	2 3/8"	5/8"	9"
3 1/4"	3 1/8"	2 7/16"	6 1/2"	6"	3/4"	6 3/4"	1 3/4"	2 5/8"	3/4"	9"
3 1/2"	3 3/8"	2 7/16"	6 1/2"	6"	3/4"	6 3/4"	1 3/4"	2 5/8"	3/4"	9"
3 3/4"	3 5/8"	2 15/16"	7"	6 1/2"	3/4"	7 1/4"	1 3/4"	3"	3/4"	10 1/2"
4"	3 7/8"	2 15/16"	7"	6 1/2"	3/4"	7 1/4"	1 3/4"	3"	7/8"	10 1/2"
4 1/4"	4 1/8"	3 7/16"	7 1/2"	7"	3/4"	7 3/4"	2"	3 1/4"	1"	11 1/2"
4 1/2"	4 3/8"	3 7/16"	7 1/2"	7"	3/4"	7 3/4"	2"	3 1/4"	1"	11 1/2"

CROSSHEADS.

The formulæ for figuring crossheads to be used with the above designs of piston rods were not obtained, but drawings of the crossheads were furnished. A standard formula in terms of the diameter of the rod could not be derived to cover all the sizes. The dimensions of the crosshead hubs for cast-steel crossheads of the "alligator" type are given in Table IV and Fig. 3, and will probably answer in lieu of formula.

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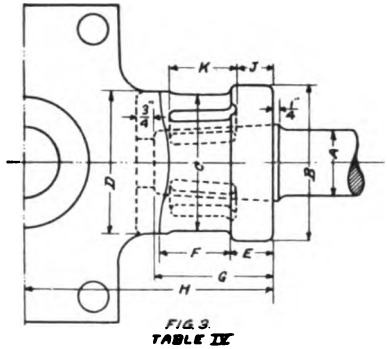


FIG. 3.
TABLE IX

Diam. of Rod A	B	C	D	E	F	G	H	J	K
2 7/8" 3"	6 1/2"	5 3/4"	6"	1 3/4"	3"	5"	10 1/2"	1 1/2"	2 13/16"
3 1/4" 3 1/2"	7 1/4"	6 1/2"	7"	2"	3 1/4"	5 3/4"	12"	1 3/4"	3 1/8"
3 3/4" 4"	8"	7"	7 1/2"	2"	3 3/4"	6 1/4"	13"	1 3/4"	3 1/2"
4 1/4" 4 1/2"	9"	8"	8 1/2"	2 1/4"	3 3/4"	6 3/4"	14"	2"	3 3/4"

The limiting bearing pressure for crosshead pins is 4,800 pounds per square inch.

The bearing area of crosshead shoes, designed to be used with the above, are: Top shoes, 7 by 24 inches, and bottom shoes, 5½ by 24 inches, for piston rods 3¼ inches, 3½ inches and 3¾ inches diameter; top shoe, 8 by 24 inches, and bottom shoe, 6 by 24 inches, for piston rods 4¼ inches and 4½ inches diameter.

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GROUP II.

PISTON RODS.

Let

P equal pressure per square inch on piston.
D equal diameter of cylinder in inches.
d equal diameter of piston rod.
l equal length of rod between piston-rod center and the center of the crosshead pin.
f equal allowable working compressive stress.
r equal least radius of gyration of rod.

Then

(1) f equals $P\frac{D^2}{d^2}$

(2) d equals $D\sqrt{\frac{P}{f}}$

(3) P equals $\frac{d^2 f}{D^2}$

Under repeated alternate strains allow the compressive stresses given in Table V. (From Pencoyd experiments.)

TABLE V.

$\frac{l}{r} = \frac{4l}{d}$	Steel (70,000 lbs.)		
20	13,360	70	6,520
30	9,540	80	5,940
40	8,380	90	5,300
50	7,760	100	4,680
60	7,120	110	4,220

CROSSHEADS.

The formulæ for cast-steel crosshead hubs used in connection with the above piston rods are shown in diagram Fig. 4.

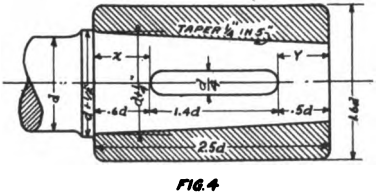


FIG. 4

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The allowable working fiber stresses are as follows:

Rod at key-way.....12,500 pounds per square inch.

Key $= \frac{d}{4}$ bearing value.....40,000 " " " "

Key = 1.4d shear.....13,400 " " " "

Hub diameter = 1.6d.....28,000 " " " "

X = .6d shear hub.....12,000 " " " "

Y = .5d shear rod..... 9,400 " " " "

GROUP III.

PISTON RODS.

The following formulæ for piston rods are expressed in terms of the diameter of rod at root of thread on piston end.

Let

P = area of piston × boiler pressure.

A = area of piston rod at root of thread.

d = minimum diameter of piston rod at root of thread.

S = working fiber stress equals 10,000 pounds per square inch.

Then

(1) $A = \frac{P}{S} = \frac{P}{10{,}000}$

(2) $d = \sqrt{\frac{A}{.7854}}$

Width of key to be less than d × 1.275.

The dimension for the piston rod in terms of diameter at root of thread on piston end is shown in Fig. 5.

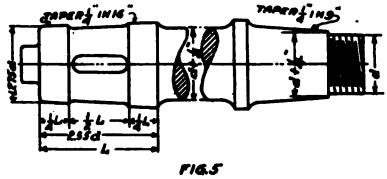


FIG. 5

The center part of crosshead fit is reduced 1-32-inch diameter so as to insure having bearing at ends of fit only.

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CROSSHEADS.

The crossheads used with the above piston rods have following dimensions of hubs:

$\frac{d}{2}$ = distance from end of hub to key-way.

Piston pressure × .00003 = thickness of metal in outer end of crosshead hub for cast steel.

Bearing area in crosshead for crosshead pin = piston pressure divided by 12,000.

The three groups of formulæ are presented as representative of the data obtained.

The committee takes pleasure in acknowledging the assistance of the parties who furnished data.

Respectfully submitted,

J. A. McRAE, Chairman,
H. C. MAY,
R. L. ETTENGER,
B. P. FLORY,
Committee.

THE PRESIDENT: Before taking up the discussion on the report just presented the Secretary will make an announcement.

THE SECRETARY: We have received this morning a letter from Mr. H. A. Houston, the young man who has the scholarship at Purdue University, who has just completed his fourth year, as follows:

WEST LAFAYETTE, IND., June 9, 1911.

The American Master Mechanics' Association, care Mr. Jos. W. Taylor, 390 Old Colony Building, Chicago, Ill.:

DEAR SIRS,— As I am completing my fourth year at Purdue and expect to receive my diploma next week, and have just written the Ryerson Company, thanking them for the scholarship which they financed, I want to thank the Master Mechanics' Association for the opportunity which was placed before me.

I have tried to reflect credit on the Association by keeping my grades up to a high standard. As you know, I was taken into Tau Beta Pi, the honorary engineering fraternity, and have just been initiated into the Sigma Xi fraternity, an honorary scientific fraternity whose membership is taken from professors and a limited number of graduates who have done original research work.

I hope at some time to be a member of the Master Mechanics' Association, and to be identified with those who have done so much to help me.

Sincerely yours,

HARRY A. HOUSTON.

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THE PRESIDENT: This paper is now open for discussion. It is another important paper, and one we are all vitally interested in, and we should be able to bring out some thoughts that will be of benefit to all of us. Mr. Kiesel, can you discuss this paper?

MR. KIESEL: I do not think I can say anything more, as I see our formulæ are given in the paper.

THE PRESIDENT: We would be glad to have the results of it.

MR. KIESEL: As to the results of the piston rods?

THE PRESIDENT: Yes.

MR. KIESEL: We allow a stress of 10,000 pounds per square inch based on maximum piston pressure and least section of the rod which is at the root of the thread in front of the piston. In order to keep the piston tight, we use a taper piston fit with the smallest diameter of piston fit one-quarter inch larger than the diameter at root of thread. The body of piston rod is half an inch larger than diameter at root of thread, leaving a half-inch for wear, but we never turn down a rod more than a quarter of an inch. Keys are usually too small. We have therefore adopted rather generous dimensions for the keys. The formulæ for the dimensions are given in the report. The stresses in the crosshead end are lower than the stresses in the body of the rod. With rods properly fitted we have not had any trouble. We have had breakages through the crosshead end, but these breakages were traced to poor fitting or too much vertical lost motion in the crosshead itself.

MR. W. E. DUNHAM (C. & N. W. Ry.): I do not know that I can add anything along the lines of this report. It covers in part a great deal of data which I had worked up some time ago on the same subject. The paper is very valuable, and it certainly will be of great assistance in checking and overcoming the troubles with our piston rods, due to weakness of design.

MR. GAINES: I want to thoroughly endorse the end-design shown on page 3, in which the fit is made one-quarter inch uniformly larger than the diameter of the rod. I think it is one of the most important things in the design of piston rods. I know from my own experience that most of the trouble with broken piston rods has been due largely to breaking through the key

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way. I attribute that to two things — one the use of insufficient metal where the key way exists, and probably an additional element due to the keying up itself, where a rod has to fit a shoulder especially, and the keys are driven home, as they usually are, by a sledge, in most instances, in an erecting shop. You put an additional load on that nobody knows what it amounts to, and the greatest trouble, in my experience, has been with rods breaking just at that point. On our older engines where we had the rods without the enlarged end, the enlarged end has been substituted when it became necessary to renew the rods, and we have entirely eliminated trouble from that source.

I have a formula which I have been using for a number of years in designing piston rods, and I do not know whether it is better or worse than that given in the report, but will present it for what it is worth. It is a rational formula, in the first place, with a constant derived from checking over a very great number of designs and getting a value for that constant. A piston rod must be treated, more or less, as a long column, and Euler's formula reduces it to the form.

$$d = S\ C\ \sqrt{D\ L}$$

where d = required rod diameter.
S = steam pressure.
C = a constant, depending on nature of material.
D = diameter of cylinder.
L = unsupported length (from crosshead pin to center of piston head).

[From analyses of a large number of engines where the size of rod has proven satisfactory, a value for "C" has been found, c — .0006.]

From a large number of analyses of rods that have given very long and favorable service without any trouble, the value C has been worked to give .0006, and I find in rechecking this very recently, after I got this paper and before coming to the convention, on some of our most recent engines, it checks out very closely, and these engines have given no trouble — I found it worked very satisfactorily.

Mr. M. D. Franey (L. S. & M. S. Ry.): On page 4, Fig. 2, and page 5, Fig. 3, the committee recommends an end bearing of the piston rod against a shoulder in the crosshead at

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the end of the socket or piston-rod bearing. I consider an end bearing between piston rod and crosshead on a locomotive bad practice.

A careful inspection of piston rods having this design proves that very few rods coming from road service have this bearing. The end of the rods are cut away by the engine-house men, providing 1-16 inch clearance. The few rods having this end bearing were found to be working in the crosshead fit or bearing.

I have seen cases where the shoulder was broken out of the crosshead while drawing the piston rod to place. I prefer and recommend the removal of this shoulder lengthening the taper fit on the piston rod accordingly, and provide a projection of 3-16 inch on the end of piston rod to take the thrust in driving the rod out of the crosshead.

MR. WILDIN: Following up what the speaker has just said, I notice there are two designs shown in the report, one on page 3, where there is a shoulder shown for the end of the piston rod, while on pages 4 and 5 there is no shoulder shown. I inquire from the chairman of the committee what is the significance of showing two designs?

MR. MCRAE: Fig. 1 is the piston end, and the diagram on page 4, Fig. 2, is the crosshead end. Fig. 3 on page 5 is the crosshead hub.

MR. BENTLEY: I was very glad to hear from Mr. Gaines that he overcame his trouble by putting larger ends on the piston rods and still use the key. We have gone into the large end piston rod, but I am sorry to say we have not overcome our difficulty with the piston rod ends breaking, due to the driving in of the key. On our last engines we have gone to the nut on the crosshead end, and I would like to ask the gentlemen present which they think is the better proposition. It seems to me you do not know what you are doing when you drive a key in, but when you tighten up a nut you have some idea what is going on.

The point brought up by Mr. Franey about the shoulder on the piston rod, where it butts up against the crosshead, is a good one. I do not believe you can get the fit in both places all the time. You must either have a fit in the crosshead, and it will

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not fit up against the shoulder, or it will fit against the shoulder, and not fit properly in the crosshead.

I would also like to know whether it is a practical thing to try to have the two fits and maintain these conditions. The fitting up of the piston in the crosshead is a very important thing, but unfortunately a good many people do not seem to realize it, and we have had very considerable trouble at both ends, the piston end and the crosshead end, due to improper workmanship, and I believe if more care were given to that work it would probably result in fewer failures. I think in the old days they used to grind them in, especially in the crosshead, to be sure they got an absolute fit, but I do not think there is much grinding done in these days.

MR. GAINES: I want to reply to Mr. Bentley's remarks relative to the use of the nuts. I do not think there is any argument on the proposition that the nut is infinitely better. I presume most of you recall the design worked out by Mr. Thomas, of the Southern Railway, several years ago, of a crosshead with the use of nuts for securing the piston rod, and that is in very general use down through in our part of the country, and I must say, that the causes of any trouble from that kind of piston rod are greatly eliminated by the use of the nut — it is away ahead of the practice which uses the key.

With relation to the remarks regarding the shoulder, I agree that you can not have two different kinds of fit and make them both fit. I think you must leave the shoulder out, rather than the amount of metal that is there, and depend on the drawing up of the taper fit.

MR. FRANEY: Our present practice of fitting the piston rod into the crosshead is to turn a nice, smooth, even bearing, nearly to size, in a lathe having a taper attachment, driving the rod to place and noting the bearing. The rod is then brought to final size and finished by filing out the tool marks.

We have tried grinding to finish with emery and do not consider it as satisfactory as the above method.

In keying the piston to the crosshead on engines leaving the main shop, one man keys all piston rods to place, using a master key to draw the rod to place and the final key to hold it.

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MR. SELEY: I desire to endorse Mr. Gaines' statement about the use of the Thomas crosshead. I think the use of the key is a barbarism in a way, because you can not tell how much pressure the weight of the sledge will yield, to drive the key in, whereas you can limit the length of the wrench, and to a certain extent the length of the pipe on the wrench, that is used to put on the nut. I think it is very desirable practice, and I would suggest in the printing of this paper in the Proceedings, if it would be agreeable to the committee, that some reference to that style be included in the report.

THE PRESIDENT: Mr. Ettinger, you have used the nut, I understand, and we would be glad to hear from you.

MR. ETTINGER: We have on lines in the South a great many of what is known as the Thomas crossheads, that is the crossheads with the piston rods held with two nuts, and as far as I know we have comparatively few failures from broken piston rods, but we do have considerable trouble with the piston rods getting loose in the crossheads, probably due to the short length of the piston rod in the crosshead fit. Broken rods have been practically eliminated by the use of this type of crosshead, but on account of the limitations in the length of the crosshead fit and the strength of the fastening, we are not using it on our heaviest power or engines larger than those having 22-inch cylinders.

MR. MACBAIN: What I am to say may be a little bit off the straight path of the subject, but I would like to ask the convention whether any one has ever made an investigation into the cause of trouble with the fits. We have used all fits known to the craft at various times, and we started in at the beginning of 1909 on the New York Central railroad to keep a record of every cylinder head broken, and rods broken through the key-way, and at the end of the year we made an analysis of the whole thing and found 90 per cent of the breakages occurred on the left side of the engines. We then started in to stiffen up the cylinders, cock rigging. We put in a heavier tumbling shaft across the front end so the left cocks would open when the right cocks opened, when engine was using steam, and the results of the change were very beneficial indeed.

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MR. RINK: Our practice on the Central R. R. of N. J. regarding the piston fit referred to on page 3, is to make the diameter C the same as the diameter A. We never have any trouble with that style of a fit. Regarding the crosshead end, we had established that same rule, and followed the practice for about ten years, making the diameter of the enlarged end on the crosshead fit the same as the diameter of the rod.

In looking into the matter recently we found that we removed hundreds of rods on account of the cracking between the key-way and the large end of the taper fit. The cracks did not extend all the way through. They simply extend to about one-sixteenth to one-quarter inch, so that our practice now, and has been for the last three months, is to make the enlarged end of the rod one-quarter inch larger in diameter than the rod proper.

Another thing, I note, referring to the figure on page 4, that they call for a taper of three-quarters inch in 12 — our practice is a taper of one-half inch in 12. I believe the former is preferable. We use practically that same method of fit, but we have now cut off the extension marked C, as we find it has not sufficient value to warrant its continued use. The only cause to which I can ascribe the crack at the large end of the crosshead fit is simply that the rod fit is perfect from the small end up to about two-thirds of the way, and then there is a slight weaving motion which causes these cracks to generate. The average life of a large number of our rods is four years and a half. Three hundred and thirty-six rods were examined and 59 showed cracks as mentioned above in or near key-way, which led us to the use of the enlarged fit in crosshead. I might also mention that we have provided clearance between the end of the rod and the crosshead. We simply insist on the one fit, and that is only on the tapered portion.

THE PRESIDENT: Are there any other members who desire to discuss this paper?

MR. JOHN A. PILCHER (N. & W. Ry.): It is our practice on the Norfolk & Western Ry. to use a shoulder on the crosshead end. This shoulder is one-half inch larger in diameter than the rod itself, and one-quarter inch larger in diameter than the

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largest portion of the taper fit, leaving the largest portion of the taper fit one-quarter inch larger in diameter than the main portion of the rod. We do not have any epidemic of broken rods. Of course, there is an occasional rod broken, but no great number.

We use the key almost exclusively, on account of the reduction in the length of the fit.

MR. CROMWELL: We use the practice largely as outlined in the paper. Formerly in our older locomotives we did not enlarge the crosshead fit, but since we entered upon the practice or doing so, it has helped matters very considerably. We find that there is one little matter of detail that is a further step toward improvement, and that is, to round the edge of the keyway, and remove the sharp saw-tooth edge, by filing it off, to about one-eighth or three-sixteenths inch radius, which prevents the starting of a crack. This is a simple matter, but it helps very materially in overcoming these troubles.

I do not believe we will ever prevent the breakage of piston rods when we use a key, if we use the rod a sufficiently long time to cause failure by repeated keying. The point should be to avoid disconnecting the piston rod from the crosshead, making the rod sufficiently long so that when you want to renew the packing rings, you can disconnect the front end of the main rod and shove the crosshead ahead to expose the piston head, in order to renew the ring. My point is to take away the necessity for removing and replacing the key, because we can, with sufficient keying, finally break the rod.

MR. GAINES: Several years ago when the Vauclain four-cylinder engines were put into use, probably everybody who had anything to do with them had trouble with broken piston rods, until they put a clamp in the middle of the guides to hold them together and keep them from springing. That stopped the trouble. That started me to looking into the condition of the guides on our engines, and I found in many of the older and lighter type engines, the guides were so light there was undoubtedly a great deal of broken piston-rod trouble caused by the springing of the guides allowing flexure. Where the guides were made heavier, in engines which had previously given trouble

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from that source, we found that the difficulty was entirely overcome.

THE PRESIDENT: If there is no further discussion we will ask Mr. McRae to close the subject.

MR. MCRAE: There is not much that I have to say. I will mention, however, in regard to the cracks or checks in the piston rods, between the face of the crosshead hub and the key-way on the rods, without enlarged ends, I have seen these cracks or checks on piston rods with ends enlarged one-quarter inch, therefore it would not seem to be due to the size of the rod. I do not know how to account for these checks. Part of the discussion refers to shop practice more than to formula. I have no further remarks.

THE PRESIDENT: The next paper will be the Report of the Committee on "Repair Equipment for Roundhouses," Mr. C. H. Quereau (N. Y. C. & H. R.), chairman of the committee.

Mr. Quereau presented the paper, as follows:

REPORT OF THE COMMITTEE ON REPAIR EQUIPMENT FOR ENGINE-HOUSES.

To the Members:

Your committee is impressed that this is a most important problem, worthy of careful study, and that on its correct solution efficient railroad operation depends as much as on any other single item in connection with train operation. We realize that no one solution will fit all conditions and that each engine house should have special study. At the same time, we believe there are a few general principles which should be kept in mind in the design, personnel, equipment and management of all engine-houses.

Originally the word "roundhouse" was undoubtedly descriptive, but for a number of years it has not been. In short, there are at present few modern roundhouses which are round. Though there probably has been no confusion or uncertainty arising from the use of the word, for the sake of accuracy we venture to suggest the advisability of substituting the word "engine-house."

It seems axiomatic that locomotives should be worn out in legitimate service as soon as possible. The capital invested in a locomotive represents a certain total of earning capacity, and the sooner this total earning capacity is realized the greater will be the yearly returns on the capital invested. In other words, a locomotive should be in service, earning as

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large a percentage of the time, and in the engine-house or shop, spending as small a percentage of time and money, as possible.

It also seems self-evident that the greater the efficiency of a locomotive, both in hauling capacity and fuel consumption, the greater the earnings of the capital invested in it, so that the conclusion that it should be kept as nearly as possible at one hundred per cent efficiency seems reasonable.

If it is a sound business proposition to wear out locomotives in service in as short a time as this can be done legitimately and to keep them as near one hundred per cent efficiency as possible, these principles should be kept in mind in determining the extent to which repairs should be made at engine-houses, and this policy, once settled, in turn largely determines the repair equipment needed. In this connection we should not overlook the fact that any repairs made at engine-houses, more than light running repairs, increase the main shop capacity to a corresponding extent.

In order to obtain an approximate estimate of the net daily earnings of a freight locomotive, the following calculations have been made. The gross freight earnings of a trunk line for the year 1910 were divided by 365 to get the average daily gross freight earnings. This result was divided by the total number of freight engines owned, plus nine-tenths of the switch engines owned. It was assumed the operating ratio for freight service was 60 per cent, leaving 40 per cent net operating income. The result was that $45 was found to be the approximate daily net operating income from each locomotive engaged in freight service. This computation assumes each freight locomotive was in service every day. This means that we could afford to invest $900 capital at 5 per cent in engine-house repair equipment for each extra day in service we could obtain for each freight engine owned, by making the repairs at the engine-house instead of at the main shop. Expressed more concretely, it means that, if the engine-house repair equipment kept each of 100 freight engines in service two extra days a year, the extra net operating income would be 5 per cent on a capital of $180,000. This does not necessarily mean an increased net operating income, as it may, and in the end probably would, mean a smaller capital invested in freight locomotives.

While the fixed charges at main repair shops do not appear in reports showing the cost of locomotive repairs, it is evident they enter into costs and should therefore not be ignored. With a view to determining approximately the importance of this item, the figures for a shop at which no car repairs are made, repairing about 600 engines during 1910, have been taken. The average cost of repairs per engine, including labor and material, was found to be about $1,200, so there must have been a considerable proportion of the engines which received only medium and light repairs. This plant, including land, buildings, machinery and tracks, has a book value of about $1,000,000. Assuming that 10 per cent of this value repre-

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sents the fixed charges, these amount to $100,000 a year, or slightly less than $170 per year per engine receiving repairs at that point. It is interesting to note that the fixed charges amount to between 15 and 20 per cent of the total amount charged at this shop to engine repairs for 1910.

The cost of fixed charges for another shop, at which, with the exception of some miscellaneous work, only locomotives are repaired, amount to $234.94 per year for each engine repaired, and are 13.2 per cent of the total value of the plant.

In all probability it will be conceded it would be a waste of time and money to run a locomotive to the main shop to have a driving-box cellar repacked or the flues cleaned. Why? Because it would involve time lost from revenue service getting the engine to, through and from the shop, reducing the yearly earnings of the engine; necessitate the use of main shop space, increasing the capital invested in shops, or reducing the main shop output; congest the shop-track movements and disarrange the shop routine, thus delaying other more important shop work. At the main shop, though the item does not appear in the statistics showing the cost of repairs, there are the shop fixed charges, including interest on the investment, repairs, taxes and insurance, a no inconsiderable item. At the engine-house the fixed charges would be very much less, as they would not include those of the engine-house proper, the tracks, turntables, ash pits, coal chutes and other facilities necessarily provided, and would cover only the comparatively small investment in the shop building and machinery provided for repair work.

There can be little room for doubt that when there is a great demand for motive power, engine-house foremen and master mechanics, rather than send engines to the main shop, though this is near at hand, will take chances, resulting in breakdowns and delays; which would not be taken if they had repair equipment of their own. In other words, with tools and men under their immediate control and responsible for results, engine-house men will, in all probability, keep the motive power in better condition, more efficient and less liable to breakdown, and take a greater pride in making repairs quickly than when repairs must be made by an independent organization.

It is, we believe, common experience that the qualifications of engine-house employees should be quite different from those of repair-shop men. The work of the repair-shop man is steady and should be accurate, thorough and first-class in every respect, with the aim that a locomotive shall remain out of the repair shop as long as possible, and there is no pressing necessity that his job be finished by a certain minute. In contrast to this, the work of the engine-house man is spasmodic; at certain hours he is extremely busy, working under high pressure, and again has little to do. His chief care is to have the engines ready for their next run and in such condition that they will make at least a round trip successfully. If he accomplishes this, he is not criticized if his work is

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not exactly to blue-print or standard and rather coarse. His training makes him fertile in make-shifts to "get the engines over the road" without a breakdown or delay, which the shop man would, and should, refuse to countenance.

Probably because of this difference in ideals, viewpoint and methods of the shop man and engine-house man, when an engine goes to the main shop from the engine-house to have a certain part repaired it usually happens that a considerable amount of other work is done which would not have been done at the engine-house and could just as well have waited till a general overhauling was needed. In other words, when repairs, other than general, are made at the main shop, more work is usually done than is necessary. It is very likely the further fact that the shop man's experience is not such as to educate his judgment as to what work he can with safety let go, prompts and impels him to do more than necessary. Whatever the cause, there can be little doubt as to the fact. To those lacking the experience, it no doubt seems that this practice could be stopped by the issue of proper instructions and supervision, but proper instructions do not change human nature or life-long habits, nor does a reasonable amount of supervision seem to work the miracle.

It is commonly the case at engine-houses that tools are frequently missing or inefficient for lack of repairs, resulting in considerable useless expense not only for tools, but in time lost in hunting them and exasperating delays in making repairs. We believe the remedy for this is a toolroom, with some one in charge whose duties should include not only the issuing of tools on checks, but as well keeping the tools in good condition and a proper supply on hand.

If a locomotive must lay in the engine-house a day for lack of the material necessary to repair it, there follows a loss of earning power which, if expressed in dollars, would pay a good interest on a considerable investment in storeroom stock. It requires no labored argument to convince a motive-power official that a storeroom in connection with an engine-house is an essential, but not all of them appreciate its relation to the earning power of the equipment for which they are responsible. It is the opinion of your committee that a reasonable business basis on which to determine the most economical amount of stock to carry at engine-houses, assuming, of course, that stock carried is only that needed for engine-house repairs, is its effect in increasing the earnings of the locomotives.

We believe there should be kept at all important engine-houses an ample supply of spare parts, such as air pumps, lubricators, injectors and bell ringers, which should be used to replace defective apparatus whenever it will take less time to exchange than to repair, and as a general proposition, that important repairs to such accessories can be made to the best advantage at the main shops, where special tools and

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machinist specialists are available. It seems evident that the interest on the investment in spare parts must be less than the loss in earnings resulting from not having them.

The conditions under which engine-house work is of necessity done are much dirtier and more inconvenient than in the repair shop, and the rates of pay usually not so attractive. It follows that to get and keep a desirable class of men, engine-house conditions should be made as attractive and convenient for them personally as possible, including good ventilation and heat, lockers, toilet and washroom accommodations kept in first-class condition. It seems to us particularly important to have a system of ventilation which will quickly and thoroughly carry off the steam and smoke, which are necessary in an engine-house, that work may be done more rapidly and efficiently than would otherwise be the case.

It is not an unusual policy in equipping important engine-houses to use worn-out and obsolete tools. We believe this is short-sighted, not only because a big shop is better able to find profitable use for such tools and better able to keep them in repair, but engine-house conditions warrant the best of tools. If a tool is not efficient enough for repair-shop work it will generally pay to scrap it.

We should, therefore, when studying the requirements of round-houses, determining the kind of work to prepare for and the repair equipment needed, have in mind the following points:

Locomotives should be held out of service for repairs as short a time as possible.

Should be kept as near 100 per cent efficiency as possible.

The effect on earnings of time saved by repairs made at engine-houses.

The effect on engine efficiency of repairs made at engine-houses.

The smaller fixed charges for repairs made at the engine-house, compared with those at the main shop.

The effect of storeroom stocks on engine earnings.

Engine-house men should have ideals and methods quite different from those of shop men.

It is important that engine-house conditions and facilities should be attractive and convenient to get and keep good men and increase their efficiency.

These conclusions can be generalized in the statement that locomotive repairs and repair facilities at engine-houses are warranted when they will result in increased earnings either because of more or better engine service obtained from a given number of locomotives.

C. H. QUEREAU, Chairman,
W. H. FETNER,
H. P. MEREDITH,
A. G. TRUMBULL,
J. A. CARNEY,
Committee.

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APPENDIX.

Engine-houses may conveniently be classified under three heads: Those at minor division terminals, or the outlying ends of branch lines, where only very light repairs are made; those at important division terminals, and not in connection with important repair shops, and those in connection with repair shops.

At outlying engine-houses we assume there would be no power-driven machines and suggest the following list of tools, the number and sizes to be determined by local requirements:

- Twist drills.
- Drill sockets.
- Taps — including machinists', steam-chest, pipe, wash-out, straight and taper, stay bolt.
- Dies to correspond.
- Pipe stock and dies.
- Hacksaws.
- Straight edge.
- Flue tools — caulking, rolls, expanders, beading.
- Pipe cutters.
- Jacks, sledges, drifts, crowbars, saws, brace and bits.
- Twist drills, extra long.
- Drill chucks.
- Ratchets and braces.
- Surfacer plates.
- Tinners' bench shears.
- Reamers, rod and taper.
- Wrenches, socket, crowfoot, hexagon.

In considering equipment for engine-houses at important division terminals not connected with repair shops, it is assumed there will be no dissent to the opinion these should be equipped with all such tools and appliances as will expedite the movement of locomotives through the house and keep them in first-class repair as far as this can be done without a backshop overhauling. It will take but little thought to convince the inquirer that the returns on capital wisely invested in such tools will make big returns when the resulting increased earnings of the capital invested in locomotives is considered, not only because of the time otherwise lost in going to, through and from the main shop, but, as well, the fact that locomotives sent to the main shop for specific repairs almost invariably receive more than these, the additional repairs not postponing the date of the final shopping and being almost inevitably made because of the training and point of view of the repair-shop forces — men and foremen — as mentioned in a preceding paragraph. Nor should it be forgotten that engine-house repairs will reduce the delays due to breakdowns and increase engine efficiency.

As local conditions vary and as conditions should largely determine facilities, it follows that your committee's recommendations can be only general. With this understanding, we submit the following suggestions. In general, we believe an engine-house should be equipped with driving and truck wheel drop pits and tools to take care of all necessary rod work, driving-boxes, ordinary valve-gear work and the replacing of flues needed

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between general overhaulings. In most cases it will be found that work of the nature indicated above can be done with but a very small addition to the engine-house force, because of the fact that, without this work, the men are, from the nature of the conditions, idle an appreciable part of the time. In line with this, some roads have found it economical to have always at the engine-house for general repairs an engine not needing heavy boiler work.

The list of tools suggested for outlying engine-houses, to be expanded to meet the requirements of a larger terminal:

Ample storeroom stock.
Drop pit for driving-wheels.
Double blacksmith forge, face plate and tools.
72-inch boring mill.
Driving-wheel lathe.
38-inch tire turning-lathe.
Planer.
Slotter.
Sensitive Drill.
Bolt cutter.
50-ton hydraulic press.
Power-driven valve-setting machine.
Air hammers.
Hot-water washout facilities.
Drop pit for engine truck and tender wheels.
Portable blacksmith forges.
36-inch boring mill.
24-inch lathe.
16-inch lathe.
Shaper.
36-inch vertical drill.
Emery grinder.
Pipe-bending machine.
Punch and shear.
Air compressor.
Air motors.

For engine-houses in connection with repair shops, the committee has not been able to agree. Several of the members feel that it is economical to depend on the main shop for considerable machine work. On the other hand, the other members believe that, except for tire turning, the equipment should be practically the same as for an independent engine-house, because of the saving of time and cost of repairs and the different training of engine-house and shop men.

THE PRESIDENT: Gentlemen, you have heard the report of this committee, which will be received if there is no objection. From a commercial point of view we are all vitally interested in this subject, as it means capital invested. As we all handle engines in roundhouses, and are familiar with the various conditions and requirements, it would seem there should be a very active discussion on this subject.

MR. WILDIN: I ask the committee if they really mean what they say on page 2: "It seems axiomatic that locomotives should be worn out in legitimate service as soon as possible." It has

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always been my idea that you should make them last as long as possible in legitimate service. I do not believe the committee means just what it says. It should be our aim to make them last as long as possible. You can easily wear them out.

THE PRESIDENT: Mr. Rae, of the Louisville & Nashville R. R., ought to be able to give us some very valuable information on this subject.

MR. RAE: I think the paper is a very valuable one, but I feel like Mr. Wildin, that the committee does not mean what it says about wearing out engines. I do not believe I can say anything further than what is contained in the paper.

MR. QUEREAU: I thought I would wait until the end of the discussion before I made any further remarks. However, there is evidently a misunderstanding as to the meaning of the committee which should be cleared up. The committee uses the expression that "locomotives should be worn out in legitimate service as soon as possible" to indicate that an engine should be on the road earning money instead of in the roundhouse; that you should wear it out as soon as possible in legitimate business.

MR. H. S. HAYWARD (Penna. R. R.): I think the committee is perfectly justified in that statement. In my opinion, too many engines are kept in service after they become obsolete for the demands of a modern railroad. They should be worn out during the period of usefulness of that type of engine. The demands of our service are constantly increasing — we are getting larger engines — and I expect that nearly all of us find we have a number of engines on hand that are not of a character suitable to our roads. I remember years ago when I was a very young man I was told by one of the eminent railroad men of that day that no engine should exist after ten years of service — it should be worn out legitimately in service during that time. But I will guarantee that there are many roads which have engines in use for fifteen or twenty years, and they are still using them at a disadvantage, compared with engines of modern type, suited for the service in which these old engines are employed.

MR. BENTLEY: I think the New Haven Railroad is in the same box as many of the other roads. We had a mania for

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scrapping engines some time ago, but now we put new boilers on the engines that we thought we ought to have scrapped several years ago, and we keep them in service. Many roads have gone too far in scrapping their small engines. In some cases they are running a ten-car engine on a two-car train, and that is not economy.

MR. GAINES: The committee has given us an excellent report on repair equipment for engine houses, and the report appeals to me very forcibly. I know some years ago, when I was master mechanic, I had on my division a very hard point to look after in an outlying roundhouse. We had very little facilities, very little material or supplies with which to perform the necessary work, and it impressed the matter on my mind so forcibly that ever since then I have been more or less of a crank on roundhouse equipment.

I thoroughly believe in the necessity of having such facilities at roundhouses and terminals that you can do all the necessary running repairs thoroughly and quickly. Further than that, I believe in having such conditions at your roundhouses that men can work under them — that is, in the winter time you should have your rooms sufficiently heated and ventilated, and there should be other sanitary facilities provided for the comfort of the men. These are things ordinarily overlooked in a roundhouse. I have found from experience, if you provide a good modern roundhouse, well heated and ventilated, that the improvement in your output and the class of work performed is marvelous.

I wish to call attention to a point made by the committee with regard to the necessity of establishing a tool room. I do not think any roundhouse of any size can exist and perform its proper functions without a tool room, and a man in charge of the room both day and night. There is another reason for that in most of the roundhouses — the men do not have access to the storeroom of the company for small supplies, and it is necessary to keep small supplies in this tool room where they are available day and night, and can be procured for use in making quick repairs.

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Another point made is the separation of the roundhouse from the back shop work. The roundhouse in a large terminal should be separated entirely from the back shop, with all the necessary equipment in the roundhouse required to take care of the ordinary running repairs, without having to depend on the back shop.

I differ from the report in one respect, that at outlying points they do not recommend any tool equipment. I think, of course, this is a matter which depends on the surrounding circumstances, but nowadays when electric power is available in many of our smaller outlying points, through the city lighting system, I think wherever it is possible we ought by all means have a drill press and lathe, and a few other tools, a dry grinder, if it is possible to obtain the necessary power, and if it is not possible to do this, it is advisable to install a small gasoline engine, to give temporary power for emergency uses in making repairs. There is no question that there is a great deal of time lost in drilling with a ratchet and things of that kind. If you have the power to operate these machines, you can facilitate the work of making repairs very greatly.

MR. E. A. MILLER (N. Y. C. & St. L. Ry.): I notice in the second paragraph on page 1 there is the following: "In short, there are at present few modern roundhouses which are round."

I would like an explanation of that. We are just in the act of building a new roundhouse on our road, and if there is anything new I would like to have the benefit of it.

MR. GAINES: In answer to Mr. Miller I would say that we have recently completed a roundhouse where in one part of it we ran two tangents, forming a right-angle corner, and we use that as a machine annex shop, and we have found it one of the most valuable adjuncts we could possibly have. There was space right back of the roundhouse proper for a machine shop. It has been found very convenient and useful.

MR. CHAMBERS: While I thoroughly agree with the committee on points of equipment of engine houses I wish to say that I have found it one of the best aids for engine repairs to do proper back shop work. I think when an engine is turned out in the back shop that proper attention must be given to avoid the

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possibility of very heavy repairs in the engine house. There are many things while an engine is stripped down in the back shop that can be done for about one-quarter of the expense that they could be done for three, four or five months afterward. It is true that you must have the necessary lathes and good drop pit facilities. I have found different places throughout the country where attempts were made to operate engine houses without drop pits to take care of driving-box fitting. It simply encourages an engineer to run an engine with a box pounding here or there, when if they had had a good drop pit the trouble would have been discovered and remedied at once. As to the point of one hundred per cent efficiency, I think we can safely say that on the Central R. R. of N. J. that is what we attain; that is the only kind of a locomotive to operate, as I think any one who operates in and out of New York will agree.

MR. DEVOY: I do not think there is any paper that has come before the convention at the present time which deserves more consideration than does this one. I agree with the committee that a roundhouse man should be a specialist. In my opinion, the back shop is the proper place to manufacture. The men in the roundhouse should be equipped with tools which will permit them to get an engine in shape quicker than in any other place.

If there was one thing that pleased me and which I think should receive the attention of the convention it was the remark of Mr. Wildin when he said there were too many ten-car engines pulling two-car trains. If the proper thought is worked out we will get back say twenty-five per cent of our engines to the old eight-wheel type. I feel justified in saying that, for the reason that the average eight-wheel type or American type of locomotive, pulling, say, up to a six-car train, will cost on an average from two to four cents per mile for its maintenance. If one of a larger type, say, three times as large, is put on that service it is an absolute impossibility to maintain it for less than seven or eight cents a mile. It is an absolute impossibility to deliver horse-power in one of the modern simple engines at anywhere near the same cost that it is in one of the smaller engines. So that if we do call attention to the fact that economy must be practiced, in my opinion we must go back at least ten or fifteen

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years. The fact that an engine ten years old is no good is the farthest away from helping the treasurer to be on the right side of the fence of anything that I can imagine. There is not any question but that two-thirds of the money of the mechanical department on a railroad is spent in roundhouse work and the other third in back shop work.

In the past three months it has been a problem, in order to make both ends meet, to see how quickly we could get an engine lying on a side track waiting for repairs, into service, and I think that everybody should discuss this paper — especially along the line of the ten-car and the two-car proposition suggested by Mr. Wildin.

THE PRESIDENT: Are there any further remarks to be made on this subject?

MR. MANCHESTER: I agree with that portion of the committee's report that speaks of engines being kept in service. One of the things that I discovered in connection with engine-house service is that there is too great an amount of dead time between the time the engine is cut loose from the train or leaves the roundhouse and is attached to the train and the time it is in the roundhouse undergoing repairs or in position to have attention given to it.

The best equipment that can be applied in the average roundhouse is that their coaling facilities, water facilities, clinker pits — and clinker pits, generally, I think is the key-note of the whole situation, because whenever you are trying to get your engines to run fast you come right up against the clinker pit and find that you are hung up there; and then when you do get your engine into the roundhouse there should be a great many devices for quick and ready repairs. Drop pits are absolutely essential, and I believe they are generally the practice in modern roundhouses. In many sections of the country boiler washing is a most important feature in a roundhouse, and everything that goes to the quick handling of boiler washing and speedily getting a boiler back in shape and ready to return to service adds greatly to the time consumed and the advantages gained by the engine being in the roundhouse. I do not believe there is any economy that will

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ever come by restricting a roundhouse in such tools and facilities as are necessary for the quick handling of repairs. The great trouble with many roundhouses is that they try to make them repair shops as well as roundhouses. I think that should be cut out. The building-up work should all be done at the shops. A roundhouse should have to do with the putting together of things that can be readily dismantled and the getting of them back into service.

THE PRESIDENT: Mr. Enright you have had a great deal of roundhouse experience.

MR. ENRIGHT: I agree heartily with the committee in the statement that a roundhouse should be provided with certain tools to expedite the handling of running repairs, but I do not believe that a roundhouse should be depended upon to make repairs that should have been made in the back shop while the engine was undergoing general repairs, for the reason that when engines leave the back shop and go into service, they should be in condition to turn as quickly as possible without the necessity of extensive repairs that would cause delays. Particularly is this true, in my opinion, with roads not burdened with an excessive motive power.

MR. MCCARTHY: I agree with the last speaker that sufficient tools should be kept in the roundhouse to handle engines with as little delay as possible. In fact, I quite agree that the system of doing such work as dropping wheels, the handling of rods, and work that will cost perhaps $150 or $200 or even as high as $300, can be done in the roundhouse with economy.

MR. BENTLEY: One of the speakers spoke of back-shop repairs as being made in the back shop. When an engine is in the back shop the repairs ought to be made there, and made thoroughly, so that when the engine gets to the roundhouse the men will have comparatively little to do on it. I believe it is a very good plan in the roundhouse to have an engine undergoing repairs all the time. There are lulls in the business and rushes in the business, as I have found in my experience, and it is a difficult matter to keep all your men engaged on running repairs all the time. Whereas, if you had an engine tied up in the round-

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house undergoing repairs, while it may cost a little more to repair it, it would keep your men occupied at all times. Of course, in case of a rush you could draw your men from that engine and put them to work on running repairs.

MR. ANGUS SINCLAIR: In connection with the remarks made by the gentleman from the Denver & Rio Grande about roundhouses, I would say that I left a western roundhouse many years ago to come East. I thought I would find many things in the roundhouses in the East that were never dreamed of out in the wild and woolly West. When I started from my western roundhouse I traveled around the country a good bit; I went through New England; I went down through the South; I went through Pennsylvania and Ohio, and in fact pretty much all over the country east of the Mississippi, and I never came across such good roundhouse work as I found west of the Mississippi. That seems to continue to the present time. Somehow the western men have got on their mettle. They try to do the work as cheaply as they possibly can with few facilities, and, gentlemen, they make the best of the facilities they have. It seems to me the tendency in the eastern part of the country is to follow up things in the way they did at the beginning and not make them very much better. [Laughter and applause.]

MR. R. D. SMITH: We have on the Boston & Albany R. R. as good engine terminals as there are in the country anywhere. We believe that sixty per cent of the maintenance of the locomotive should be expended in the engine house to insure the best road service, and forty per cent in the shop. We have arranged our coaling plants in such a way that an engine may get coal outbound as well as inbound. One reason for doing so is that with the complicated front ends on our engines it is almost impossible to get at the flues from the front end, and they have to be blown out from the rear end. It is also quite important not to take coal inbound when repairs are required on the tanks. The clinker pits are arranged so that the ash pans can be cleaned and the grates examined, outbound as well as inbound, and it is also possible to look after the dampers and other parts that are important to get in good condition for road service.

We have found when handling a large number of engines

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that a good drop-pit section is very important. We have our drop-pit sections arranged from 100 to 112 feet long. I think this is perhaps a little out of the ordinary, but it enables us to move an engine with the doors closed so as to drop out any wheel under it and get at any part easily.

We have at each of our engine houses three pits connected together in the drop-pit section. We think it is good practice to keep an engine in the roundhouse on the pit on which the force may be employed when not engaged on other work.

We believe it is the little things to be done in a roundhouse that go to make up good service, and quite agree with, and desire to emphasize the note on page 5 of the committee's report, where it says it is important that engine-house conditions and facilities should be made attractive and convenient, and thus increase the work and the efficiency of the men. We have in our new terminals everything that goes to make for the comfort of the men and their convenience in the way of light, heat, toilet facilities, etc., and by keeping the place clean and tidy we do get better service.

MR. DEVOY: When we were discussing the matter of a key on a piston rod and a nut, Mr. President, I was fully convinced that if I had to go over all the years that I have been designing the work the first thing I should do would be to go to the roundhouse and find out whether it was easier to get a key out of a crosshead than it was a nut. I used to think that a formula was the whole thing, but let me tell you that if you go to the average roundhouse man with a formula you will sit down and put in the whole day and be working formulæ until your head is worked off.

There is a question that I would like to ask Mr. Smith, of the Boston & Albany, because he got after me yesterday on the Ringelmann chart matter; I would like to ask him if his road would recommend the extension of drop pits in roundhouses, especially in cities where space is cramped, to 150 feet in order to permit the movement of an engine after you had dropped a wheel?

MR. SMITH: Yes, sir; decidedly.

MR. DEVOY: Well, I wouldn't care to go to the management and recommend it. I should much rather put a motor on my

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turntable, with a wire rope, to drop the wheel in that way than to build an extension of the drop pit. Even if you leave the engine outside, why, nine times out of ten she is dead, and the little exposure will not hurt her at that time. Besides, it would be very expensive to get the necessary land in some of our cities for such a purpose, especially in cities where you have got to pay $500 a foot for it.

MR. PRATT: I did not hear the last speaker say what road he was connected with, Mr. President. [Renewed laughter.] Now, I venture the assertion that any supervising motive-power officer who is not a roundhouse crank or engine-house crank lacks something that otherwise might tend to his greater success. I believe all of us, especially those who have had a roundhouse training, are very much interested in this subject and that we have a great deal of sympathy for the men now holding roundhouse positions, as their work is even more exacting to-day than ours was a few years ago.

I want to say a word with regard to the results of Mr. Smith's experience on the Boston & Albany Road. His roundhouses and terminal facilities appear to be very modern, but I must say from the way he pronounced the word " Boston " I should imagine that he too came from West of the Mississippi River. [Laughter.]

The drop-pit extension, which he mentioned, is in line with the practice we are following in our later work. Until eight or ten years ago we did not have any trailing wheels, and then our engine-houses were built so that we merely arranged for dropping any of the driving wheels. At that time our tank wheels had arch-gear trucks. It was very easy to take a tender wheel out. Furthermore, the fact that the modern railroad appears to have the consolidated engine in the majority — there are four pair of tank wheels and one pair of engine truck wheels to be dropped in the drop pit. If these truck-wheel pits have an extension permitting the movement of the engine, why, you can take out any pair of tank wheels or a truck wheel and still keep the engine inside the roundhouse wall in bad weather.

I agree, I am sorry to say, with what Mr. DeVoy says concerning small engines [laughter], but the Chicago & North Western and several other western roads occupy a different position from

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the Rutland Railroad, the New York, New Haven & Hartford and other roads that have more trunk lines and less branches; some of our difficulties have been that we are running two-car engines on ten-car trains, so that the bugaboo that is now mentioned does not seem so terribly impressive to some of us western people.

On page 2 the committee capitalizes the net freight earnings per locomotive. I have had a little experience myself in capitalizing various things, and I can assure you that it depends on which side of the fence you are which way you will check the figures. I notice that $900 a day for the 365 days in the year represents a total capitalization of $328,500, and that this would buy, at the rate of $20,000 per locomotive, 16 engines. Now it seems to me that there is some fallacy in the statement in that paragraph. They say that is equivalent to freight earnings of $45. Of course, you can not controvert that. But you will have to show us in the West why you can not get that same result by adding another locomotive.

At the expense of being called old-fashioned, I am going to say that I believe there are many places where we can make that saving by assigning engines regularly. We have the pool on our brain so much that we oftentimes pool engines where their mileage is not up to the average of the engines on the system. Wherever regular locomotives can be assigned and good average mileage attained, I believe it will show something much more interesting than is shown in this statement of the paper.

THE PRESIDENT: Gentlemen, we are an hour behind in our work and we have five more subjects yet to consider. I dislike to cut off this discussion, but it is 12 o'clock and I think we will proceed to the next subject.

MR. LOVELL: Mr. President, before you close on this subject may I just add one word?

THE PRESIDENT: Yes, sir.

MR. LOVELL: I have been very much interested in this paper and in the discussion on it. I fail to find any reference made to one very important element in the equipment of a large roundhouse, and that is an overhead traveling crane. I think an over-

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head traveling crane is a very essential feature in the modern roundhouse. A few years ago while on a Western road I had occasion to install an electric traveling crane in a new roundhouse that was being built, and the results were so satisfactory and the economy in its use was so great, both in the time saved and in the labor required in handling heavy parts of the locomotive, that a considerable number of such traveling cranes have since been installed on the same line. Recently I had occasion to make recommendation for a new roundhouse in the East, and one of my recommendations was that an overhead traveling crane should be installed. The management of the road made inquiries where there was a roundhouse where such a crane could be seen in actual service, and I was unable to locate one any nearer than the Santa Fe Road. If there are traveling cranes anywhere in the East in roundhouses I should be glad to be advised where they are and what result is being derived from their use.

THE PRESIDENT: Now I will ask the chairman of the committee to close the discussion.

MR. QUEREAU: I will only say in closing that it was not the intention of the committee to go in details, but simply to discuss the subject on its broad general grounds. The list of tools to be kept at a terminal roundhouse was not intended as one that should be applied to all terminal roundhouses everywhere. We simply said, in giving this list of tools, that we assumed that there would be no power-driven machinery. In other words, that is a list of tools for use in roundhouses where there is no power. We specifically stated that each roundhouse must be considered by itself.

I dislike to appear to reflect on my good friend Smith, but if he will look at page 7 he will see that we do recommend the drop-pits he has referred to.

The opinion has been expressed that an engine can not be maintained at the roundhouse as cheaply as at the back shop. Now I can not speak authoritatively on behalf of the committee, but for myself personally I am very much inclined to doubt that. On the contrary, I am of the opinion that a road which does sixty per cent of its repairs in the engine-house and forty per cent of its repairs in the back shop will maintain its engines in better

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condition and at a less expense than the road which makes sixty per cent of its repairs in the back shop and forty per cent in the engine-house. There are several factors entering into that. We must not forget that we are only one branch of a railroad. If an engine breaks down on the road it simply means in our statement "engine failure." It means to the Transportation Department freight delay, overtime and other expenses that we can not figure on. For that reason ample facilities for repairs at roundhouses I am personally persuaded will pay. Then, too, we should not lose sight of the fact — not because the committee calls attention to it, but because it is a fact — that while we do not show in our cost of repairs the fixed charges, yet it is there just the same, and the fixed charges saved by repairs made at the engine-house will probably mean a saving of from $150 to $200 per engine each year. This is an item that it strikes me is well worth bearing in mind. [Applause.]

THE PRESIDENT: The next paper, gentlemen, is the report of the Committee on Best Method of Treating Water for Locomotive Use. Mr. H. E. Smith is chairman of this committee.

Mr. Smith read the report of the committee as follows:

REPORT OF THE COMMITTEE ON THE BEST METHOD OF TREATING WATER FOR LOCOMOTIVE USE, WHEN THE DENSITY OF TRAFFIC DOES NOT WARRANT WATER-TREATING PLANTS.

To the Members:

Until within a few years, only two methods for the prevention of incrustation in steam boilers have been prominent, namely, boiler compounds and water-softening plants. The former, which include the familiar soda ash, aims to keep the incrusting substances in a soft, pulverulent condition until they can be blown or washed out of the boiler.

In locomotive service one of the difficulties connected with the use of boiler compounds is in applying them proportionally and regularly to all of the water. The plan of putting the matter in the hands of the engine crew was early found to be a failure. The next step was to put the dose for a whole trip into the tender tank at the beginning of the run. This method involves a considerable and possibly harmful excess of compound at the beginning, and a corresponding deficiency near the end of the run. The obvious remedy is to transfer the base of operations from the locomotive to the wayside tank.

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To secure this, as well as some other advantages, separate softening plants have been adopted and have easily proved their usefulness. For small stations their use involves the difficulty of high fixed charges per unit of water treated.

The small station must be able to respond to occasional heavy consumption for short periods and a softening plant having sufficient capacity for this purpose becomes expensive during normal times.

A very useful compromise between the two systems of treatment is an apparatus of simple construction which will mix the water uniformly with the proper proportion of some chemical solution which, although it will not actually remove incrusting solids, will act as a boiler compound in keeping them in a soft condition in the boiler. If a fair storage capacity is provided, partial removal of incrusting matter may also be effected.

The work of the committee indicates that few railroad officers realize the importance of this idea or the benefits to be derived from its systematic and intelligent application.

At track-trough stations soda ash (or other material) may be thrown directly into the trough, in regulated quantity, after each train passes. This crude but fairly effective method is used on one road at four stations, pending the installation of automatic devices.

Much more systematic is the plan of pumping the solution with the water. This plan is used by seven roads. A small branch may be run from the water-pump suction to a tank of solution and the flow of the latter be regulated by a valve. This method has the advantage of producing a thorough mixture during the passage through the pump, but also sometimes causes deposits on the valves of the pump which interfere with their action. It is found preferable to pump the soda with a small power pump actuated by direct connection with some moving part of the water pump, thus insuring a correct proportional feed of solution. The discharge of the chemical pump should be carried to the large water tank independently of the water. In the water tank the chemical pipe should discharge close to the main water inlet in order to produce satisfactory mixture. As it is not practicable to run the small chemical delivery pipe for long distances, this system is not desirable when the tank is more than 100 feet from the pump house.

When distances are greater the chemical apparatus should be separated from the pump house and transferred to a point close to the water-storage tank or to the top of the tank itself. In such cases, the chemical pump may be actuated by a positive displacement motor or water wheel through which passes all, or a definite aliquot, of the water to be treated. While such a device has long been used in full softening plants, it is not used for the simpler treatment, so far as the committee has learned, except on one road (the L. S. & M. S.). The same arrangement is suitable when water is taken from city supplies where the railway company has no water pumps.

For pumping chemical solutions, simple single-acting outside packed plunger pumps with outside check valves are much to be preferred.

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Plungers one to two inches in diameter and of six to ten inches stroke are sufficient. Their attachment to any convenient moving part of a water pump is very simple.

The essentials of the arrangement recommended for the usual wooden tub, when it is located near the pumping station, are shown in Fig. 1. The water and chemicals mix in the central compartment, which may be merely a wooden box, and pass down and out at its bottom, rising gradually in the main part of the tank. The water is drawn off through the floating pipe and a sludge valve is also provided. Fig. 2 shows a similar arrangement for a steel tower. Owing to the larger settling space in the tower, a floating outlet is not necessary. If the water wheel or motor combination is required, it can be arranged as shown in Figs. 3, 4 and 5.

The choice of suitable chemicals for the treatment of water under the conditions covered by this report is limited. It is very important to avoid the production of any sediment whatever, or else to provide both time and space in which to separate the sediment entirely. The separation of sediment in the pipes must obviously be avoided.

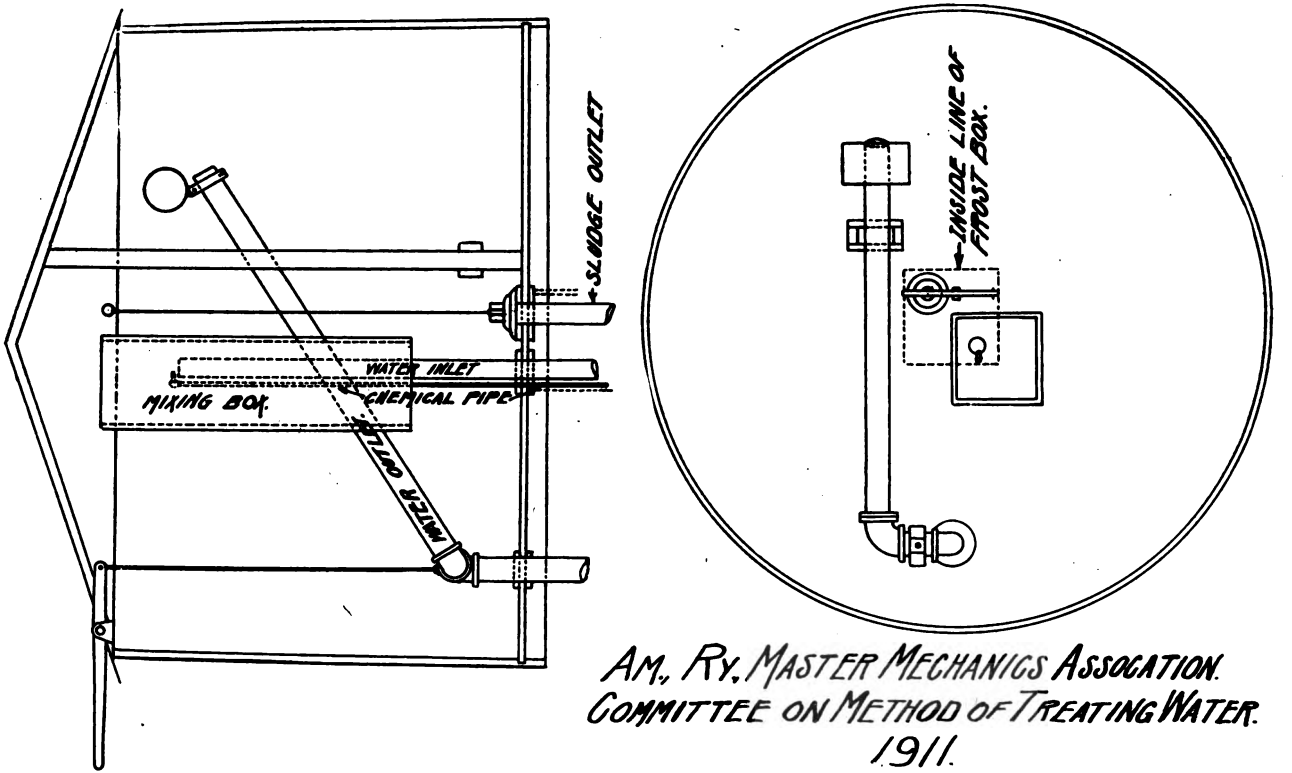
When sediment must be avoided, as in ordinary wooden tanks when the water is used within two to four hours, soda ash, or possibly bicarbonate of soda is the only reagent available. The latter is least apt to produce sediment. Neither reduces the total amount of incrusting matter, but both change it all to carbonate, or bicarbonates, so that hard scale is largely avoided.

This treatment has been found very beneficial on a number of roads. It is applicable to waters of moderate hardness. With very hard waters the amount of soda required to decompose the incrusting matter is liable to cause deposits. In this use of soda ash, as well as with soda ash placed directly in the tender tank, blowing and washing out must be done thoroughly at regular and sufficiently frequent intervals.

In the opinion of the committee the case well merits the small further elaboration of process and apparatus, sufficient to separate a considerable amount of sediment. For this purpose a steel tower, as shown, and the use of caustic soda are recommended. With correctly proportioned apparatus and proper adjustment of the soda, a water of twenty or more grains of incrusting solids, of which 25 to 50 per cent is "permanent hardness," may be reduced to ten grains, of which all is carbonate. In this manner a very troublesome water is reduced to one which will give very successful service, with reasonable care of boilers. So far as the committee is aware, this process is in use only on the Lake Shore & Michigan Southern, although after this report was practically complete it was learned that the Philadelphia & Reading used it some years ago.

One other reagent deserves mention and that is barium hydrate. It has the great advantage of treating sulphates without introducing foam-producing alkali. When sulphate of lime is treated with barium hydrate, the lime ultimately finds its way to the sediment as carbonate of lime and the barium goes the same way as sulphate, insoluble in the water, which

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FIG. 1.

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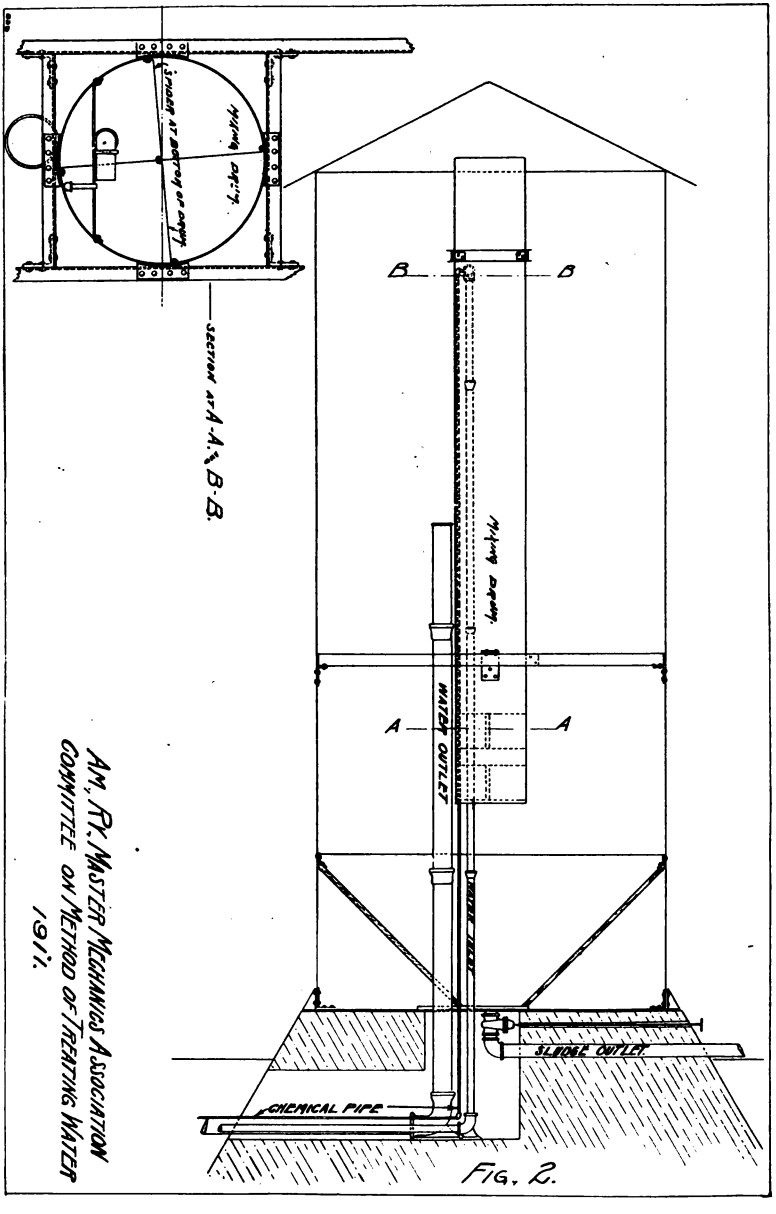


FIG. 2.

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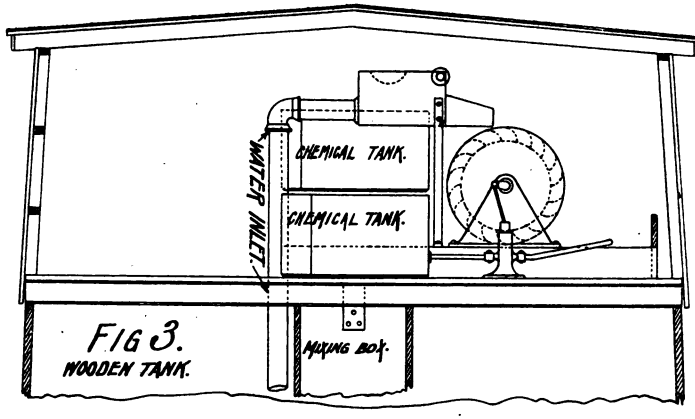


FIG 3.
WOODEN TANK.

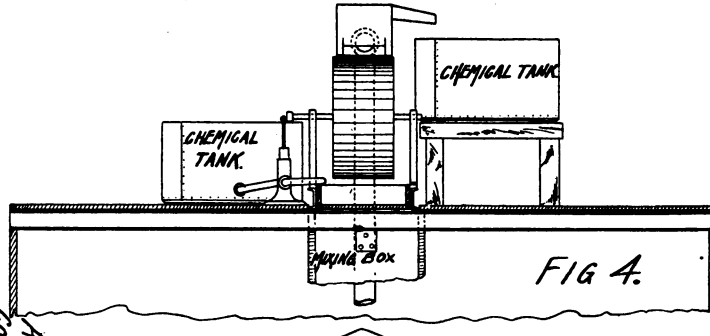


FIG 4.

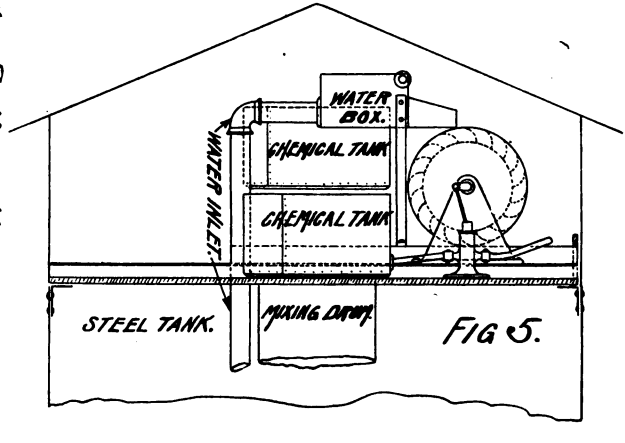


FIG 5.

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is then left entirely free from all the compounds concerned in the reaction. It should be borne in mind that barium hydrate is poisonous. The principal objection to its use is its cost. Not only is its price per pound higher than that of soda ash, but more pounds are required. It has, however, been used by a few roads on very high sulphate waters which could not be treated satisfactorily with soda. Theoretically, three pounds are required to do the work of one pound of soda ash in treating sulphates. In actual work, one road reports that five engines were treated one month with 4,290 pounds of soda ash costing $42.90, but, although this was all that could be used on account of foaming, the boilers were not clean. It was estimated that about twice as much, costing about $85, would have kept the boilers clean if it could have been used. For the same engines 13,000 pounds of barium hydrate, costing $390, was sufficient to keep the boilers clean. It must be borne in mind that these waters are very much worse than the average boiler water of the country.

Finally, it is urged that water purification of any kind should always be supervised by a competent chemist. The raw water should be analyzed occasionally and the chemical solutions, as well as the treated water, should be tested frequently.

Respectfully submitted,

H. E. SMITH, Chairman,
F. O. BUNNELL,
L. H. TURNER,
J. E. MECHLING,
J. J. CONNERS,
Committee.

THE PRESIDENT: Unless there is objection, the paper will be received, and it is now open for general discussion.

MR. M. E. WELLS (W. & L. E. R. R.): I would like to inquire if any one present has tried the use of barium hydrate? If so, I would like to know what his experience has been.

MR. ANGUS SINCLAIR: I have had considerable experience in my time in trying to eliminate impurities from feed-water. I had the pleasure of acting as a railway chemist at one time, with special attention to the prevention of scale and other impurities in boilers due to bad water. That made me pay a great deal of attention to what different railroads were doing with regard to their feed-water. I might say that this reminds me of a story told in the Highlands of Scotland. It was a district where there were few inhabitants and no doctors, and a traveler wanted to know what they did when anybody got sick. A native answered:

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"Give them a drink of whisky." "But," said the traveler, "if that did not help the patient what would you do then?" "Give him another drink," was the reply. "Suppose the second drink didn't do him any good, then what would you do?" was the next question. "Well," said the native, "if a man is so bad that he can't be helped by whisky, then he isn't worth helping." [Laughter.]

So it seems to me that the same remedy is followed with the treatment of feed-water. There are certain waters that contain elements that cause encrustation, and they are not the same in all waters. Yet, you take the same dose and apply it to them all, and, if the dose you give doesn't remedy the evil, you think the case isn't worth curing. The fact of the matter is that all bad feed-waters should be under the supervision of a chemist who is able to tell by analysis what should be done and what elements will put the bad encrusting matter out of solution. That is something that is not understood by every man connected with a feed-water station, and it ought to be systematically attended to if any remedy is attempted at all. I think the greatest disappointments in connection with water purification, or the preventing of the bad effects of hard water, have been ignorance in the treatment.

THE PRESIDENT: Mr. Dunn, can you give us any light on this subject?

MR. J. F. DUNN (D. S. L. Ry.): We have used both systems; that is, treating the feed-water in the wayside tanks by the introduction of soda ash and lime, also using a compound introduced into the engine tender, our experience being that we got good results from both but consider the use of the compound preferable owing to there being no expensive cost of installation. It is compounded under the direction of a chemist after the analysis of the different waters being furnished him and it has reduced our flue failures materially, also the trouble we had previuosly with the cracking of fire-box plates. It is handled in cans, the latter being placed on the engines by the hostlers or hostler helpers, and, while at first the enginemen did not take to it kindly, they now like it so much that they do not care to go out on the road without the regular quantity of this compound being placed on their engine.

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MR. A. G. TRUMBULL (Erie R. R.): We have had some experience with the use of compounds on the Erie Road and we have experimented with various systems for treating bad water out in Indiana. The water we have to contend with presents as difficult a problem in connection with encrusted solids as is found anywhere in the country. As a general proposition, we believe the proper thing to do is to treat the water before it is introduced into the boiler. I believe a little study on the part of any one of the results produced from solids found in boilers will convince them that that is the most desirable practice. We have two recognized standards of treatment which have been highly successful, and we reduced our boiler-washing period very considerably after its introduction, and have obtained very good results in the way of boiler maintenance generally. We have had some experience also with the soda-ash treatment, and while that may be a temporary expedient to employ where great difficulty is found with bad water, nevertheless it is only a temporary remedy and ought to be replaced with some more modern scientific method.

MR. CHRISTOPHER: I have had a great deal of experience with bad water on our road. In dry seasons of the year the water analyzes as high as seventy per cent sulphur, and we have found we were creating sulphuric acid in our boilers. I had difficulty in converting the management of the road to the necessity of treating this water. At our way-station pumps the water was largely diffused with rain water and melting snow, but through June, July, August and a part of September, we had very great trouble with it. We used a compound. In fact, I have used a compound of some sort for thirty years. This compound was dumped in the tank, and it was good for all the water in the tanks over a stretch of 180 miles or more. I am satisfied that if any one follows up this compound they will realize that it is like dumping water into a lake. The only proper way to treat bad feed-water is to treat it and then discharge it in the tank. We find that we have to vary our treatment of this water as close as forty-eight hours. Therefore, it is quite necessary that the operator shall have full knowledge of the variations that are taking place in the water that is flowing into these stations. In some of the creeks I have found as high as twenty streams of sulphur

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water, the odor of the sulphur being so strong that they could detect it at a distance of 100 feet from the stream. Through the wet season with soda and hydrates of lime we reduced that as much as eighty per cent, and then we have to run it up again, in the dry season. We have had flues leak on our consolidation engines every trip. Since the treatment of this water in this way we only touch up the flues at every wash-out, which is about once in two weeks. The life of the fire box is prolonged to the extent that the fire-box work alone will pay for the tank in a very few years. The operation of the tank is conducted at very little expense. We have a wheel connected with the discharge pipe and a current of water flowing through this discharge pipe operates a wheel which provides power for the agitator, and also at the same time drives a pump for throwing the chemicals into the top of the high tank.

THE PRESIDENT: Has any member had any experience with the barium hydrates in treating water? Mr. Bean, have you?

MR. BEAN: No, sir, but I wish to say that our experience has been similar to that of the last speaker. Our system of treatment is managed by our chief chemist. I can not go into details of that system, but do know since it was introduced it has worked very well, and has increased our mileage on a set of flues, from 15,000 to 40,000. We are installing at the present time water-treating plants quite extensively at points where we still have untreated water that is very bad. We have found by experience where treating plants were first installed, that through this means it has increased the life of fire boxes, from twelve months to as high as seven years. It is well understood that this treatment of the water makes the water foam, which foaming is held down by the systematic use of boiler compound.

MR. REDDING: Judging from the remarks made by the last two speakers, I believe we have the same system of treating water that is in use on their lines, the water being treated in the way-side tanks at all water stations and practically all of the solids are precipitated in these treating tanks. Our main difficulty arises when the water in the rivers is low and badly polluted by mill and mine drainage so that it requires heavy treatment to bring down

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the solids. This treatment results in loading the water with sulphate of soda which causes the water in the boilers to foam and results in the necessity of using anti-foam compounds and the liberal use of blow-off cocks. I had hoped to hear some discussion as to the merits of the several devices on the market by the use of which the water from the injectors is not delivered directly into the boiler, but is given an opportunity to become heated before reaching the hotter portion of the boiler, and for which I believe claims have been made that a portion of the solids could be trapped and the volatile matter allowed to pass off in the steam.

MR. PRATT: I should be glad to answer Mr. Redding as to what to do to prevent the foaming on what we call over-treated water. We have some water that in order to remove the considerable amount of encrusting solids requires over-treating, and which causes more or less foaming, where we apply blow-off cocks liberally to the boiler near the mud ring, and use them for five to ten seconds at short intervals. Our former practice was to blow out locomotives at the terminals or when standing at outlying places, but we have had much better success in avoiding foaming and preventing leakage of flues by blowing out practically between every station. Those are detailed instructions to the men, and they are quite generally carried out. We ask the men in charge of the engine, if there is any trouble, for an explanation of it, and if they do not blow out once at every station they are disciplined. I may say that our stations average, perhaps, six miles apart. We have not had a failure from foaming engines, that I recall, in six or eight months, whereas there used to be a great many each day.

With regard to installing water-treating plants at wayside stations, it has been our custom to ascertain the number of pounds of encrusting solids in the water per 1,000 gallons and the number of gallons used at any feed-water tank in twenty-four hours. In that way we would first install a treating plant wherever the greatest number of pounds of encrusting solids developed in twenty-four hours. That did not always mean where the poorest water was. It was sometimes found in comparatively good water. The plants have been extended, and the poorer waters are treated

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in this way. We always use soda ash quite extensively where we have none of these treating plants.

MR. D. J. REDDING: I would like to ask Mr. Pratt if he has any data to show whether it costs any more to use anti-foaming compound than it does to make continuous use of the blow-off cocks, thereby blowing away large quantities of steam and water which it has cost money to heat. I would also ask if they have experienced any trouble in the use of blow-off cocks between stations, particularly in congested districts where there would seem to be liability from damage to property or injury to persons through the use of these blow-off valves, while engines were in motion?

MR. MANCHESTER: The question raised as to barium hydrates: We have had a little experience on a branch in South Dakota where the water was of such a character that in order to soften it so that it could be used in the locomotive it became overtreated and was too light and we used the barium hydrate there for nearly a year with very satisfactory results.

As to the anti-foaming compound: Instead of blowing out, there is a large territory in South Dakota in which alkali water is the only reliable source of supply; the hard waters are too scarce to be relied upon, and we are using an anti-foaming compound in connection with that water. It does very nicely until the concentration of alkali gets up between 600 and 800 grains to the gallon, and then we begin to have trouble even with the anti-foaming compound. Then we have to commence the blowing-out process to keep it below 600 grains.

MR. WELLS: I did not understand what Mr. Redding meant about putting water into a boiler so that it would not foam. I think it is pretty well understood that the foaming principle in water is carbonate of soda or other soda salts, and the only way they can be taken out is by evaporation. It can not be treated out. You always get carbonate of soda when you treat sulphate of calcium with soda ash. That is why I was especially interested in this barium hydrate because it treats the sulphates of calcium and does not leave any foaming trouble. I do not know of any way to prevent the foaming with the possible exception of the

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introduction of some anti-foaming compound, but that would be only temporary and would only last a short time.

I was interested in Mr. Manchester's statement that they are able to carry the degree of saturation up to 600 grains to the gallon. We found on the Burlington Road that a boiler would begin to foam ordinarily at about 200 grains to the gallon.

I am very much interested in the barium hydrate. It is expensive now, but I believe the manufacturers can reduce the price very materially when more of it is used. I would think people who have had serious trouble with foam and especially those who have made trouble for themselves by using large quantities of soda ash, would hail with delight the announcement regarding barium hydrate.

MR. CHRISTOPHER: After we began to treat our water we had great difficulty with the foaming. We got our chemist after the difficulty and he analyzed the water, but did not understand why it foamed. He rode on some of our consolidation engines and found that the water foamed badly, and the only suggestion he could offer was that a little castor oil injected into the boiler by means of pouring it into the side plug on the injector would help. Well, it did, but I presume the purchasing agent refused to buy castor oil for the purpose, and I didn't feel disposed to furnish it myself [laughter]. However, many of the engine crews did supply castor oil themselves to save them annoyance and trouble in getting up heavy grades. The subject was camped on for some time, but there was no satisfactory solution arrived at. However, I can say that it died a natural death. We were compelled to blow off our engines at least every forty miles. The question was brought up here by some gentleman that this blowing off was blowing away money. We do not blow off at all, and neither do we experience any trouble. Our engines run two weeks between washouts, and are not blown off during that interval.

THE PRESIDENT: Mr. Gossett, can we hear from you on this subject?

MR. GOSSETT: I want to highly endorse the paper under discussion. I am now closing my twenty-fourth year in the north and western parts of the United States, in continuous railroad

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service, having served on eight different lines of road. During that time I have had to deal with some very bad water. The road with which I am now connected operates about six hundred miles in what is termed "bad-water territory." We have only from two to four trains daily; therefore, the wayside treating tank proposition is prohibitive. The water is such that it is absolutely necessary that some treatment be used; otherwise, we would get only about twenty thousand miles out of a set of flues.

For a number of years we have been using soda ash in large quantities — as high as a pound and a half per thousand gallons. This makes it necessary for the boilers to be washed about every two hundred to two hundred and fifty miles and frequent use of blow-off cocks while on the road. I recently ran a very exhaustive test with a water treatment. Such treatment is applied to the tenders only at the terminals. The test was confined to way-freight and time-freight locomotives. I selected two engines of the same class which had made practically the same number of miles since last receiving general repairs and were assigned to way-freight service — one boiler being treated with soda ash and the other with the compound. I placed a thoroughly competent observer on each engine and ran this test for a period of twenty-two days, and must say the results obtained were very gratifying, as it proved conclusively that there are boiler compounds made which will give much better results than soda ash and will relieve the necessity of maintaining way-side treating plants. It also proved conclusively that we could reduce our boiler repairs fifty per cent and double the miles per boiler-washing over what we could when using soda ash. A further saving was created of two pounds of coal per thousand ton freight mile. About the same result was obtained with the through-freight engines as that of the way-freight.

THE PRESIDENT: It would seem that the treating of water is a good deal like Mr. Sinclair's remarks about the treatment of the disease in Scotland. There are some waters you can treat and there are a whole lot of waters that you can not treat.

Now, Mr. Smith, will you close the discussion?

MR. H. E. SMITH: The committee realizes that there is no one method of treating water that is good for every road. The

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subject given to the committee, however, limited it to one particular line.

On any one road it will happen that all these methods may be necessary at one time or another, and the same rule applies to chemicals — no one chemical is equally efficient for all cases — and we wish to put ourselves on record as not advocating soda ash for every purpose, and a discussion of boiler compounds would bring us into the line of proprietary articles.

With reference to the method of injecting water to evaporate foam-producing substances, it does not appear to me personally how such methods could be carried out. As the foam producers are nearly always alkaline, especially in treated water, some volatile substances may be removed by injecting the water into the steam space with suitable baffle plates or something of that kind.

A surface cock has sometimes been found more efficient in reducing foam than the bottom blower, and it is quite frequently the experience that foam is more prevalent when a system of water treatment is first entered upon; but after the boilers are cleaned, and the old scale or mud removed, the foam disappears very largely. The discussion brings out one other point, that any system with thorough supervision produces much better results than some other system which has not been watched closely.

THE PRESIDENT: Our next report is that of the Committee on Lubrication of Locomotive Cylinders, Mr. C. H. Rae, chairman.

Mr. Rae presented the report as follows:

REPORT OF COMMITTEE ON LUBRICATION OF LOCOMOTIVE CYLINDERS.

To the Members:

Your committee on the subject, "Lubrication of Locomotive Cylinders by up-to-date sight-feed lubricators, which operate by condensation of steam, adjustable feed, etc.; also to investigate the subject of mechanical lubricators," respectfully submits as follows:

Questions submitted to members:

1. Have you experienced difficulty in lubricating modern passenger and freight locomotives, with steam pressures from 180 pounds to 230

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pounds, with the up-to-date lubricators which operate by condensation of steam, adjustable feed, etc., and, if so, state experience and causes for same?

2. What recent improvements have been made in the hydrostatic-feed lubricators, to add to their efficiency and economical operation?

Give explanation, experience and results.

3. If familiar with any device, independent of the hydrostatic-feed lubricators as furnished by the manufacturers, which increases their efficiency or economical use, give description, principle of operation, etc.

4. For the lubrication of valves and cylinders on modern locomotives, state your objections, if any, to the up-to-date hydrostatic-feed lubricator.

5. What types of mechanically operated lubricators have you used?

State method of application, principle of operation, control and regulation of feed, location of device on the locomotive, with experience and results.

6. For the lubrication of modern locomotives, valves and cylinders, state your objections, if any, to the mechanically operated lubricator.

7. Are you familiar with any method, or device, for admitting the oil into the steam before it reaches the saddle casting?

If so, state details, experience and results.

8. Have you had any experience with the oil-delivery pipe attached to deliver the oil into the steam-way in the saddle casting, instead of at the steam chest or valve chamber?

State results.

9. What has been your experience in the lubrication of locomotive cylinders where superheated steam has been used?

In this connection, state the degrees of temperature acquired, if hydrostatic or mechanically operated lubricators were used, and the results from both, where both have been used.

10. Do you consider it necessary to lubricate cylinders of locomotives using superheated steam, independently of the valves, using any type of lubricator?

11. What is your experience with the lubrication of cylinders on Mallet compound locomotives, using superheated steam with the hydrostatic-feed lubricator? With the mechanically operated lubricator?

12. Do you consider it necessary to lubricate the valves and cylinders on the high and low pressure cylinders of Mallet compound locomotive (by lubricators of whatever type) piped independently to each valve chamber and cylinder?

The replies to question No. 1 were universal in expression, that there is no serious difficulty now experienced in lubricating modern passenger and freight locomotives with the "up-to-date" lubricators of the hydrostatic-feed type.

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Several of the members, in reply to question No. 2, have referred to a recent improvement in the hydrostatic lubricator, whereby it is made possible to close or shut off feeds without interference with the feed-valve adjustments. This is an economical feature, but of such recent date that no comparative data have been submitted as to the results obtained.

The replies to question No. 3 were limited. One member replies as follows: "The automatic steam-chest choke plugs, which feed against a constant boiler pressure in the oil pipe, and not against a pressure that fluctuates with pressure in steam chest, will result in a high degree of efficiency in the lubricator."

All replies to question No. 4 indicated there were no objections.

The replies to questions Nos. 5 and 6 embody the same general information, but were limited in number.

a. "Have used several types of mechanically operated forced-feed lubricators. Three of those experimented with were driven from a moving part of the engine. This was unsatisfactory, since the feed is required that does not vary with the speed of the engine. More oil is required per minute while the engine is worked hard at low speeds than when running fast with light throttle. To overcome this we used some forced-feed lubricators with independent air motor. None of them, however, have been satisfactory. It is difficult to apply to the filling holes screens that are fine enough to keep out dirt, without restricting the speed at which the oil can be put in, and the enginemen pull them out. The consequence is that the plungers wear rapidly, and after a time the feed becomes irregular. They are troublesome to maintain, and under conditions specified, in answer to question No. 1, gave no better results than the hydrostatic lubricator.

b. "We have experimented with two or three makes of mechanical-feed lubricators, but have been unsuccessful in getting as good results as we do with the hydrostatic-feed lubricators. The trouble with the mechanical-feed lubricator seems to be due to the difference in temperature; in warm weather, or during the warm part of the day, they would feed sufficient oil, but in cold weather, or at night when the weather is colder, they do not feed as well as when it is warmer."

c. "We have used two mechanical lubricating devices, which received their motion from a connection made to the valve stem and oil chamber, and regulating devices were located in the cab. Our test record shows that after considerable experimenting the device operated fairly well, but after a time gave considerable trouble and was finally removed on account of not giving satisfactory results. Mechanical means are objectionable, in that the device is so complex, and consists of so many parts, it is difficult to keep joints from leaking. To be properly installed, all pipes must be kept constantly filled and under pressure, with return valves at distributing points. On account of mechanical movements, parts will wear, and it will be more expensive to maintain, and in making repairs

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more oil is lost than with hydrostatic lubricators. Devices of this sort do not appear to have as yet been perfected to such an extent as to make them thoroughly reliable."

d. "Have used a force-feed lubricator with pipe connections to all driving boxes and to steam chest. Operated by mechanism deriving its motion from connection to Walschart link. Lubricator located in the cab.

"While reducing friction on journal bearings, and delivering oil to steam chest, I do not consider it entirely satisfactory, for the reason that there is nothing to indicate that the pumps are working properly and delivering the oil until the valves become dry."

e. "Our objections to mechanically operated lubricators is that they are necessarily more complicated than the hydrostatic lubricator, without showing any beneficial results."

f. "Have tried some, but have not obtained satisfactory results."

g. "We have in the past used on some of our two-cylinder compound engines mechanically operated lubricators. Our objection to it was the rapid wear of the parts, leakages and annoyances."

h. "Using displacement plunger force feed. Secured in suitable location in cab, and operated by a series of rods and bell cranks, which are connected, either to eccentric blades and independent eccentric on rear, or other convenient axle, or by reducing-arm on back crank pin. Device subject to varying control, and fed by increasing or decreasing stroke of plungers by means of adjustment thumb-nut.

"Results as to economy and distribution very satisfactory. Slight trouble experienced in experimental stage, due to method of operating lubricator."

There was but one reply to question No. 7, citing experience which is herewith submitted:

a. "Present method in use with mechanically operated lubricator is to tap direct through dome into steam pipe, or throttle box. This method has proven to be superior to the old method of admitting to steam chest direct."

In this connection, and pertinent to the question, a member refers to a test:

a. "Delivering the oil from the right side of the lubricator into the left cylinder, passing it through the smoke box, and from the left side of lubricator into the right cylinder in the same manner.

"The gases in the front end superheating the oil, and evaporating the water of condensation, putting the oil into the cylinders superheated."

The substance of the replies to question No. 8 from those who have had experience was in accord with the report from a member who has tried this method extensively:

a. "On slide-valve engines consider results distinctly superior; on piston-valve engines reports vary, but general experience is that better results are obtained by putting oil into the steam passage."

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Questions Nos. 9 and 10 have been considered jointly by the members. In the information submitted, the important features of this phase of the subject are well expressed in the quotations, as follows:

a. "Superheat varies from 550 to 580 degrees. Our regular practice is to use one feed pipe to valve chest, applying it to go to each end of valve in center of the valve bushing. This lubricates valve very well, but it is questionable whether delivering oil to steam passage is not preferable. We also use one feed to each side of cylinder, at top in center. This is not used unless required. When working with full throttle and long cut-offs, over considerable distances, find cylinder feed necessary.

"There is no difficulty whatever in obtaining satisfactory lubrication in superheater engines with hydrostatic lubricators, on account of difference of pressure between steam chest and boiler, previously mentioned. In fact, there is considerably less difficulty than on engines using saturated steam. In spite of this the piston-ring wear is far more rapid."

b. "On our superheaters we carry 170 pounds boiler pressure; the maximum degree of superheat is 225. On a number of superheater engines we introduced oil both at the steam cavity and into the cylinder direct; found the latter connection unnecessary.

"The only trouble which we had with superheater engines was to get our men to use the drifting valve when the engine was shut off. If this is not done, have experienced trouble with the bushings cutting out, but on districts where the drifting valve is put on we are having very good success."

All replies to question No. 11 pertain to the satisfactory use of the hydrostatic lubricator. No information furnished concerning use of mechanically operated lubricators on Mallet compound locomotives using superheated steam.

Replies to question No. 12 were at variance as to the location of the oil pipes, but it was the consensus of opinion that piping to the high-pressure valves and cylinders only was insufficient for satisfactory lubrication.

The subject of "Lubrication of Locomotive Cylinders," though a familiar one, requires frequent consideration, to the end that the best possible results may be attained. The conditions of service are constantly changing; areas and steam pressure are increasing, and with the introduction of superheated steam and the Mallet compound locomotives, new problems, all tending toward an advanced standard of efficiency, while the demand of the hour is a decreased cost per unit of service.

The method of lubricating valves and cylinders of the heavy power in use on railways has not been materially changed since the introduction of the hydrostatic-feed lubricator, and the use of this device has become so general, that its principle of operation, and the necessary attention for its maintenance, are familiar to all who have to do with its care and operation.

The experience of your committee, supplemented by the information

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received from the members of the Association, warrants the assertion that there is no serious difficulty now experienced with the use of that device.

The recent addition of a stop-feed feature is an improvement, rather tending to economical operation than to efficiency, and it behooves the manufacturers of this device to keep pace with, or in advance of, the constantly increasing demands.

The information obtained from the members, and cited in the foregoing, confirms the experience and opinion of your committee, that a properly constructed hydrostatic lubricator meets the locomotive requirements better than a mechanically operated lubricator, for the several reasons:

(1) Familiarity with care and operation by the different classes of labor whose duties are in connection with its use.

(2) Simplicity of design and substantial in construction; the operating parts being better protected from disarrangement or breakage.

(3) A more accurate regulation of the amount of oil applied to the valves and cylinders under the varying conditions of service performed by the locomotive at different speeds and points of cut-off.

(4) Because of less complication in construction and attachments, a corresponding less expense of maintenance.

The more general custom of delivering the oil to the steam chest or valve chamber is open to question, and there has been some very conclusive evidence submitted favoring the delivery of the oil into the steam at a point where it may become highly attenuated and intermingled with the steam.

The presumed effect of extreme temperatures, due to high pressure and superheat upon the oil, has been an objection to delivering the oil in the steam before it reaches the cylinder saddle. Information has been furnished and confirmed by the experience of some of the members, that the efficiency of a properly compounded mineral cylinder oil is not seriously impaired when protected by the steam.

As the reports on this particular feature of the subject are indefinite, your committee recommends further consideration and experimentation.

The information obtained from the members who have had the most general and extended experience with locomotives using superheated steam confirms the experience and opinion of your committee, i. e., that the same reasons advanced for the endorsement of the hydrostatic-feed lubricator on locomotives using saturated steam apply to locomotives using superheated steam.

The information submitted and quoted in the replies, pertaining to the proper location and number of oil pipes on superheated locomotives, is of much value. The experience thus far is not sufficiently conclusive to justify a decisive recommendation at this time.

We would, however, particularly recommend that liberal openings be given to drifting valves, and attention to their proper manipulation, that

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the temperature of the cylinders may be promptly reduced within the lubricating possibilities of the oil when exposed to the atmosphere.

The problem of satisfactorily lubricating the Mallet compound locomotive is still in process of solution. At present it seems essential to pipe independently to the high and low pressure cylinders. However, your committee has been advised that there has been some experience, with satisfactory results, by eliminating the pipes to the low-pressure valves and cylinder, substituting an auxiliary oil pipe to the receiver with the high-pressure steam connection. This carries sufficient oil over to the low-pressure cylinders to insure good service.

Increased efficiency and reduced expense of operation confronts the mechanical departments of our railways to a greater extent than ever before.

The final and most important recommendation of your committee is a continued live interest in the "Lubrication of Locomotive Cylinders."

C. H. RAE, Chairman,
JOS. CHIDLEY,
T. R. COOK,
J. F. DEVOY,
J. F. WALSH,
S. T. PARK,
P. M. HAMMETT,
Committee.

THE PRESIDENT: You have heard the report of the Committee on Lubrication of Locomotive Cylinders. If there is no objection, the report will be received and open for discussion. Mr. Chambers, have you an engine equipped with forced feed or mechanical drive speed, one of your high-speed engines?

MR. CHAMBERS: Mr. Redding, of the P. & L. E. R. R., has one of his engines so equipped, but I am not familiar with it.

THE PRESIDENT: The subject is open for discussion.

MR. G. L. FOWLER: I would ask if Mr. Sweeley, of the shops of the Long Island Railroad, is here? They have been experimenting with a mechanically operated cylinder lubricator for some time, and I think they have some information on the subject.

THE PRESIDENT: Mr. Sweeley does not seem to be here.

MR. FOWLER: If he is not here, I will simply repeat some information that I obtained the other day from Mr. Muzzey, who is mechanical engineer for the road. They have been experi-

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menting for the last six or eight months with a mechanical lubricator for cylinders in which a mixture of oil and graphite is pumped into the steam chest. It is operated mechanically, and after a run of about two hundred miles, the faces of the steam chests, valve seats and cylinders become coated with this film of graphite, and as far as that one engine is concerned the operation has been very successful and very satisfactory, and they are inclined to think that it will reduce the internal friction of the engine to such an extent as to produce some saving in fuel.

There have been no data published, but it has been so successful that they are about to make an extensive trial, I understand, of some eight or ten engines, with which very exhaustive tests will be made to determine exactly what can be done from both a mechanical and economical standpoint in developing this method of feeding.

The lubricator is so constructed that the old trouble of the graphite settling and becoming a sediment in the bottom of the oil cup is done away with by the mixture which keeps it stirred up until it is actually deposited in the steam chest. Hence, the operation is wholly satisfactory. There are no data available, as I understand it, as yet, but there will be in the course of the next eight or ten months, after these investigations have been completed.

THE PRESIDENT: Is there any further discussion on this subject? Our time is limited, and if you want to discuss the paper, we will be glad to have you do so promptly. We have only one-half hour left for the balance of our work.

MR. MILLER: We have found that very good results can be obtained by applying the graphite from a separate cup, separate from the lubricator, applying it at the commencement of each trip. We find very satisfactory results from applying this graphite cup to our steam chests in addition to the regular lubricator.

MR. G. A. HANCOCK: We have fifty engines, with the steam temperature about 535 to 565 degrees. We tried the mechanically operated lubricator and found it unsatisfactory. We had trouble on our connections with the ordinary lubricator. Instead of admitting the oil directly through the cylinder and valve, we con-

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nected the oil pipes direct to the steam passage. This, in connection with a small amount of graphite, gave satisfactory service. We are allowing for our freight engines one pint of valve oil for every forty miles, and one pint of valve oil for every sixty miles in passenger service.

THE PRESIDENT: If there is no further discussion, I will ask Mr. Rae to close the subject.

MR. RAE: I have closed the matter in the report, and I do not think there is anything to be added to it.

THE PRESIDENT: The next report is that of the Committee on Consolidation, Mr. D. F. Crawford, chairman.

REPORT OF COMMITTEE ON CONSOLIDATION.

MR. CRAWFORD: Mr. Chairman and gentlemen, the report of the committee will not take up all the time allotted to it. At the last meeting of the Association the committee was instructed to ascertain if there would be any objection to the consolidation of the two Associations. An attorney has been consulted and the committee reports that the consolidation can be carried through legally. That really carries out the instructions that the committee received at the last convention. In view of the President's remarks, in his address yesterday, it would seem desirable to have the committee continued on this subject.

THE PRESIDENT: Is there any discussion on this subject by the members?

MR. BENTLEY: I move that the committee be continued. Motion seconded and carried.

THE PRESIDENT: We will now have an individual paper on "Locomotive performance under different degrees of superheated steam," by Prof. C. H. Benjamin. The paper will be presented by Prof. L. E. Endsley.

Professor Endsley presented the paper as follows:

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LOCOMOTIVE PERFORMANCE UNDER DIFFERENT DEGREES OF SUPERHEATED STEAM.

I.— Introduction.

To the Members:

1. The work done by Dean W. F. M. Goss, reported by him to this Association in 1909, and the further work done by the authors of this paper, reported to the Association in 1910, seemed to show a progressive improvement in the efficiency of the locomotive with an increase of superheat. It was also apparent that the improvement in the efficiency had not reached a maximum, but continued to grow as the temperature of superheat increased. For this reason, it seemed desirable to attempt still higher temperatures, and to determine, if possible, any maximum point in the curve of efficiency. The locomotive Schenectady No. 3 has accordingly been equipped with a Schmidt superheater, giving substantially more superheating surface than the ones formerly used, as may be seen by reference to figures in this report. This has rendered possible the use of still higher temperatures, so that, whereas in previous experiments a maximum of about 200 degrees of superheat was obtained, from 200 to 275 degrees were used in the experiments described in this report.

Two conditions were to have been expected in these experiments: first, practical difficulty with the lubrication of the slide valve; second, less rapid improvement in economy at the higher temperatures. Neither of these conditions has been realized. Practically no difficulty was experienced with the lubrication of the valve and no maximum of economy has been reached. As far as the figures and tables in the present report are evidence, the coal consumption decreases more and more rapidly as the superheat becomes higher. There seems to be no practical limit to the gain to be obtained in this way, except the usual troubles incident to the use of superheated steam.

The present report is shaped largely on the lines of that made by the authors last year, in order to facilitate comparison. Although these experiments are not yet completed, it has seemed advisable to call to the attention of the Association the results so far obtained.

2. *Equipment.*— The same locomotive, now known as Schenectady No. 3, was used in all the tests. When used with saturated steam the locomotive was in normal condition. After the tests on saturated steam had been completed it was first equipped with a Cole superheater, and the results from tests of superheated steam, as reported to the Master Mechanics' convention in 1909, were obtained with the original superheating surface of 193 square feet (neglecting header). The work as reported last year was from results obtained after reducing the superheating surface by two successive decrements of 42 square feet each, or approximately 21 per cent at each reduction.

Prior to the experiments described in this report, the locomotive had been overhauled and a Schmidt superheater installed in place of the

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Cole superheater. In order to distinguish between the different superheaters as used on Schenectady No. 3, in last year's report, the first superheater was known as "Cole A," the second as "Cole B" and the third as "Cole C." The superheater in this year's report is referred to as the Schmidt. The heating surface of the tubes of the four superheaters are:

Cole A	193 square feet.
Cole B	151 square feet.
Cole C	109 square feet.
Schmidt	324 square feet.

The boiler dimensions were the same for all the Cole superheater tests, but in order to install a Schmidt superheater, with a larger amount of superheating surface, the number of small 2-inch flues was reduced from 111 to 107, and the large 5-inch flues were increased in number from 16 to 21. This change in the number of flues increased the water-heating surface from 897 square feet to 956.5 square feet. With the above exceptions, the boiler and engine were the same for all the testing upon the four different superheaters.

The nominal dimensions of Schenectady No. 3, as used in the tests with the Schmidt superheater, are as follows:

Type	4-4-0
Total weight (pounds) about	109,000
Weight on four drivers (pounds) about	61,000
Driving-axle journals:	
Diameter (inches)	7½
Length (inches)	8½
Drivers, diameter (inches)	68.99
Valves — Type, Richardson balanced:	
Maximum travel (inches)	6
Outside lap (inches)	1⅛
Inside lap (inches)	0
Ports:	
Length (inches)	12
Width of steam port (inches)	1.5
Width of exhaust port (inches)	3
Total wheel base (feet)	23
Rigid wheel base (feet)	8.5
Cylinders:	
Diameter (inches)	16
Stroke (inches)	24
Boiler — Style, extended wagon top:	
Diameter of front end (inches)	52
Number of 2-inch flues	107
Number of 5-inch flues	21

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Length of flues (feet)	11.5
Heating surface in flues (square feet)	956.5
Heating surface in fire box (square feet)	123.5
Total water-heating surface (square feet)	1080.0
Length of fire box (inches)	72.06
Width of fire box (inches)	34.25
Depth of fire box (inches)	79
Grate area (square feet)	17
Thickness of crown sheet (inches)	7/16
Thickness of tube sheet (inches)	9/16
Thickness of side and back sheet (inches)	3/8
Diameter of stay bolts (inches)	1
Diameter of radial stays (inches)	1 1/8

The Schmidt superheater, as used in these experiments, has the following dimensions:

Outside diameter of superheater tube (inches)	1 3/8
Number of double return loops	21
Average length of the pipes in the double return loops (feet)	42.8
Total superheating surface, based on the outside surface of the tubes in square feet	324

The total water and superheating surface of the locomotive equipped with the Schmidt superheater is 1,404 square feet.

II.— Tests with Schmidt Superheater.

3. Following the method primarily adopted, the tests on the Schmidt superheater were run at 200, 160 and 120 pounds pressure. The tests at 240 pounds were omitted because it was felt that there was no further need of tests at this high steam pressure. The speeds and cut-offs adopted for the tests were the same as those used last year. Fig. 1 shows diagrammatically the precise condition of pressure and cut-off for each test. Each circle indicates a test, and the number within the circle indicates the test number, and corresponds to the number in the summary of data, shown in Tables III and IV. These tests were all run during the months of April and May of this year.

4. *Lubrication of the Valves and Cylinders.*— Because of the fear expressed by several railroad men, that the lubrication of the valves, which are slide valves, would be difficult when using a higher degree of superheat, a transfer filler was added to the lubricator, thus increasing its capacity. After a few tests, however, it was found that no more oil was required with the Schmidt superheater than was used with the Cole superheater.

The oil used in all of the superheater tests was 600 W. The amount of oil used was approximately one drop (through a sight-feed lubricator) to each valve box for each 12 to 30 revolutions of the locomotive, and one drop to each cylinder for each 30 to 60 revolutions of the locomotive,

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depending upon the length of valve travel. That is, a short cut-off and high steam pressure required more oil than a long cut-off and lower steam pressure. The amount of oil used in a 75-mile run (this being the length of each test) varied from 1½ pints to 3 pints. This amount of oil may seem rather high to a railroad man, but to insure against the cutting of the valve, more oil was used than was really necessary, as was shown by the fact that during none of the tests was there any evidence of dry valves. An inspection of the valves and cylinder wall after all the tests had been completed showed a high polish and no cutting.

5. *Evaporative Efficiency of the Combined Boiler and Superheater.*— The fuel used in all tests was Youghiogheny lump. The equivalent evaporation (pounds of water evaporated from and at 212° F.) per pound of dry coal, plotted against rate of evaporation (equivalent evaporation per foot of water-heating and superheating surface per hour), is shown for the Schmidt superheater in Fig. 2. The equation for the line most nearly approximating all the points is

$$E = 12.45 - .318\ H$$

where E is the equivalent evaporation per pound of dry coal and H is the equivalent evaporation per square foot of water-heating and superheating surface per hour. The area of the heating surface is based upon the interior surface of the fire box, and the exterior surface of the boiler and superheater tubes. This equation is derived from all tests at all pressures, and, therefore, fairly represents the average performance of the boiler at any pressure. It is to be noted that a majority of the points which represent individual tests fall very near the average line, which was obtained by finding the center of gravity of two groups of points and drawing a line through the two points thus found. These points are shown by a cross inscribed in a circle.

6. *The Degree of Superheating.*— The method of measuring the temperature of superheated steam was the same as that employed in the tests of the other superheaters. High-grade mercurial thermometers were placed in thermometer wells in the branch pipe at a point directly adjoining the superheater header. Fig. 3 shows the superheating degrees Fahrenheit plotted against the rate of evaporation. In order to obtain a common slope for all lines for all pressures, the points were averaged in two groups and the dotted line through these two average points used as the common slope. Other lines were then drawn parallel to this line through the points corresponding to each pressure and the equations for these lines are as follows:

TABLE I.

DEGREES SUPERHEATING UNDER DIFFERENT PRESSURES.

Boiler Pressure.	Equation.
120	$T = 107 + 16.5\ H$
160	$T = 101 + 16.5\ H$
200	$T = 90 + 16.5\ H$

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In the above table T equals the superheating degrees F., and H equals the equivalent evaporation per square foot of water and superheating surface per hour. Assuming a rate of evaporation which will give approximately 440 indicated horse-power, which is 8.5 pounds, the corresponding values of T for the various pressures can be obtained. These values of T plotted against the corresponding boiler pressures are shown for all four superheaters in Fig. 4. The value of superheaters, as shown by the equation through these points, is expressed for the Schmidt superheater by the equation

$$T = 133.8 - .216\ P + 16.5\ H$$

where T equals the superheat in degrees Fahrenheit, P equals the boiler pressure in pounds gauge and H equals the equivalent evaporation per square foot of heating surface per hour. The above equation is applicable for any pressure and any rate of evaporation.

7. *The Ratio of Heat Absorbed per Square Foot of Superheating Surface to that Absorbed per Square Foot of Water-heating Surface.*— If the efficiency of the superheating surface be expressed as a ratio of heat transmitted through it to the heat transmitted through the water-heating surface of the boiler, or as the ratio of the equivalent evaporation per square foot, and this ratio be plotted for each test against the corresponding equivalent evaporation per square foot of water-heating surface per hour, the diagram shown in Fig. 5 will be obtained. Since this line represents tests at all pressures, it is seen that the efficiency of the superheating surface is increased with increase in the rate of evaporation. It is worthy of note that the efficiency of the superheating surface is equal to fifty per cent of that of the water-heating surface when the equivalent evaporation per square foot of water-heating surface per hour is 13 pounds or more.

8. *Smoke-box Temperatures.*— The temperature of the gases in the smoke box was obtained by the use of a mercurial thermometer placed midway between the diaphragm and the front tube sheet. Fig. 6 shows the smoke-box temperature for each test plotted against the rate of evaporation. The equation of the line drawn through these points is

$$T = 500 + 13.08\ H$$

where T equals the smoke-box temperature in degrees Fahrenheit, and H equals the rate of evaporation.

9. *Draft.*— The draft was measured directly in front of the diaphragm. Fig. 7 shows the draft in inches of water for all tests, plotted against the rate of evaporation.

10. *Steam Consumption Under Different Pressures.*— The points showing the average steam consumption at different pressures, Fig. 8, were obtained by averaging the steam consumption for the tests at each pressure and drawing a smooth curve through these average points. The curve has been extended beyond 200 pounds pressure to 240 pounds pressure. This extended curve was drawn approximately parallel to the

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curves obtained with the lower degree of superheat of the Cole superheater. It can be seen from the points that the water rate for 160 and 200 pounds pressure is the same.

11. *Coal Consumption Based Upon the Derived Performance of the Locomotive.*— In order to eliminate irregularities in the coal consumption as obtained from individual tests, the coal consumption was derived for each pressure from the average performance of the locomotive, the average performance of the boiler being taken from the curves in Fig. 2 and that of the engine from Fig. 8. The results are shown in Table II, and include values for each 20-pound difference in pressure from 240 to 220 pounds.

The method of obtaining these results is as follows:

Column 3, which gives the degree of superheating, was obtained from the equation

$$T = 133.8 - .216\ P + 16.5\ H$$

in which P is the boiler pressure by gauge, column 2, and H is the rate of evaporation. The line of this equation is shown in Fig. 4. In the calculations of column 3, the value of H was taken as 8.5, this being the rate of evaporation necessary to deliver approximately 440 horse-power. This represents a fair value of the performance of the engine, and is the one adopted in the work reported last year.

Column 4, which gives pounds of steam per indicated horse-power per hour, is obtained directly from the curves in Fig. 8.

Column 5, which gives the B. T. U. per pound of steam, assuming a feed-water temperature of 60° F. and a superheat as given in column 3, is obtained directly from the steam tables.

Column 6, which gives equivalent pounds of steam per indicated horse-power per hour, is the product of columns 4 and 5, divided by 970.4 (latent heat of steam at 212° F.).*

Column 7, which gives the B. T. U. per indicated horse-power per minute, is the product of columns 4 and 5 divided by 60.

Column 8, which gives equivalent pounds of steam per pound of dry coal, is obtained as follows: Assuming an average load of the locomotive of 440 indicated horse-power to be delivered under all pressures, the corresponding rate of evaporation per square foot of heating surface equals 440 multiplied by column 6 and divided by the total water and superheating surface, which is 1,404 square feet. This rate of evaporation per square foot of heating surface was substituted in the following equation:

$$E = 12.45 - .318\ H,$$

and the value of H, as given in column 8, was obtained.

Column 9, which gives the pounds of coal per indicated horse-power per hour, equals column 6 divided by column 8.

* In this connection, it may also be noted that throughout the work of calculation Mark's and Davis' "Tables and Diagrams of the Thermal Properties of Saturated and Superheated Steam" were used.

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12. *Corrected Results of Individual Tests.*— The results of individual tests, as shown in Table III, have been corrected to eliminate individual irregularities, the corrected results being shown in Table IV.

Column 16, which gives equivalent steam supplied to engine per hour, equals pounds of steam supplied to engine per hour from original log, multiplied by [B. T. U. taken up by each pound of steam in boiler and superheater minus (60 minus feed-water temperature), divided by 970.4, latent heat of evaporation].

Column 17, which gives the equivalent evaporation per pound of dry coal, was obtained by substituting for H in the equation

$$E = 12.45 - .318\ H,$$

the values in column 16 divided by 1,404 square feet.

Column 18, which gives dry coal per hour, is obtained by dividing column 16 by column 17.

Column 19, which gives dry coal per indicated horse-power per hour, was obtained by dividing column 18 by column 11 in Table III.

Column 20, which gives equivalent steam per indicated horse-power per hour, was obtained by dividing column 16 by column 11 in Table III.

Column 21, which gives the machine friction in pounds of mean effective pressure, was taken from the 1909 report by Dean Goss, Vol. 43, page 158.

Column 22, which gives the machine friction in horse-power, was obtained by using values of M. E. P. of column 21 and the speed in revolutions per minute of the individual tests, together with the indicated horse-power constant of the locomotive.

Column 23, which gives the machine friction in per cent of indicated horse-power, was obtained by dividing column 22 by column 11 and multiplying by 100.

Column 24, which gives the dynamometer horse-power, was obtained by subtracting column 22 from column 11 in Table III.

Column 25, which gives the draw-bar pull, was obtained by dividing column 22 by (.000547 multiplied by the revolutions per minute), in which .000547 is the tractive horse-power constant of the locomotive.

Column 26, which gives the coal per dynamometer horse-power per hour, equals column 18 divided by column 24.

Column 27, which gives steam per dynamometer horse-power per hour, is obtained by dividing column 16 by column 24.

III.— A Comparison of Results Obtained with Saturated and with Four Different Degrees of Superheated Steam.

13. *Basis of Comparison.*— As was pointed out last year, it seems logical to compare the four different degrees of superheated steam with that of saturated steam, since all the series of tests so far run have been under the same steam pressures and cut-offs, developing approximately the same horse-power, the only difference being the area of the super-

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heating surface and the area of the water-heating surface. As the area of the water-heating surface of the boiler with the Schmidt superheater is approximately only 47 square feet greater than with the Cole superheater, it would seem that this difference would not be enough to affect the relative efficiency of the boiler. In the comparisons which follow, therefore, no allowance is made for differences resulting from different water-heating surfaces.

In the tables and diagrams which follow, all material included under "Saturated Steam" and superheater "Cole A" has been taken directly without change from the 1909 report, and that under superheaters "Cole B" and "Cole C" from the 1910 report.

14. *Comparison of Engine Performance.*— The steam consumption of the locomotive operated under saturated steam and the four different degrees of superheated steam represented by "Cole A," "Cole B," "Cole C" and "Schmidt" are shown graphically in Fig. 9. The numerical values are given in Table V. From an inspection of these curves, it is seen that the tests with the Schmidt superheater, that is, the one giving the highest degree of superheat, gave the lowest water consumption.

The curves showing the relation between the B. T. U. per I. H.-P. per minute for the different conditions of tests are given in Fig. 10. These curves serve to emphasize the results as shown in Fig. 8.

The relation in coal consumption per I. H.-P. per hour for the four different superheaters and for the saturated steam is shown graphically in Fig. 11, the numerical values being given in Table VI. Here again the Schmidt superheater results are the smallest, going as low as 2.5 pounds per indicated horse-power per hour.

The consumption of water per indicated horse-power, as affected by the degree of superheat, is well shown in Fig. 12, in which the pounds of steam per indicated horse-power per hour are plotted against the degrees of superheat. The pounds of steam per indicated horse-power per hour were obtained from the curves shown in Fig. 9. The degree of superheat was obtained from the lines shown in Fig. 4. It will be seen that the comparisons are made at 160, 180 and 200 pounds steam pressure, these being the pressures that fall in the center of the field of experiment, and for that reason would be more likely to represent correct results.

As indicated last year, it would seem that this relation could be approximately represented by a straight line as shown. It is also seen that the water consumption for all pressures between 160 and 200 pounds for the Schmidt superheater is practically the same.

15. *Coal Consumption.*— The pounds of coal per indicated horse-power per hour plotted against degrees of superheat are shown in Fig. 13. The pounds of coal per indicated horse-power per hour were obtained from the curves of Fig. 11, and the degree of superheat was obtained in the same manner as for Fig. 12.

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The same pressures of 160, 180 and 200 were used in this comparison as in the comparison for steam consumption. This relation between the coal per indicated horse-power per hour and the degree of superheat for pressures of 160, 180 and 200 would seem to indicate, as brought out last year, that it could be represented by a curve as shown. In other words, the first 80 or 100 degrees of superheat does not make the same proportionate decrease in coal consumption as does the second 80 or 100 degrees, and, in like manner, the third 80 degrees increase makes a still greater reduction in the coal consumption. For instance, the coal consumption per indicated horse-power per hour at 180 pounds steam pressure for the locomotive using saturated steam was 3.50 pounds, and for 80 degrees of superheat it was 3.4 pounds, a gain in efficiency of 2.8 per cent; while the consumption at 160 degrees superheat is 3.05 pounds, a gain of 12.8 per cent, and the coal consumption at 240 degrees superheat is only 2.47 pounds, a saving of 29.4 per cent over that of the locomotive using saturated steam. Thus, if we take the locomotive using saturated steam as consuming 100 per cent of coal, it might be said that the first 80 degrees superheat will reduce this 2.8 per cent, the second 80 degrees, 10.0 per cent, and the third 80 degrees, 16.6 per cent, making the total reduction for 240 degrees superheat, at 180 pounds pressure, 29.4 per cent. Practically the same results would be obtained for the curves representing 160 and 200 pounds steam pressure.

16. *Conclusions.* a. A locomotive equipped with a superheater giving from 200 to 240 degrees of superheat will, during the time of running, effect a saving in coal consumption of from twenty to thirty per cent over that of the same locomotive using saturated steam.

b. It would seem that the total gain in efficiency which could be obtained from superheat in a locomotive would not be reached until the temperature became too high for practical purposes.

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TABLE II.

LOCOMOTIVE PERFORMANCE UNDER DIFFERENT PRESSURES.

SUPERHEATER	BOILER PRESSURE, GAGE	SUPERHEATING DEGREES F FROM EQUATION	POUNDS OF STEAM PER INDICATED HORSE-POWER HOUR VALUES FROM CURVE	B.T.U. PER POUND OF STEAM. FEED 60 DEGREES F. SUPERHEAT FROM EQUATION	EQUIVALENT POUNDS OF STEAM PER INDICATED HORSE-POWER HOUR	B.T.U. PER INDICATED HORSE-POWER PER MINUTE	EQUIVALENT POUNDS OF STEAM PER POUND OF DRY COAL	POUNDS OF COAL PER INDICATED HORSE-POWER HOUR
I	II	III	IV	V	VI	VII	VIII	IX
SCHMIDT "A"	240	222.2	19.5	1297.0	26.08	421.4	9.86	2.63
SCHMIDT "A"	220	226.5	19.0	1296.8	25.41	410.7	9.92	2.57
SCHMIDT "A"	200	230.8	18.9	1296.3	25.26	408.3	9.93	2.55
SCHMIDT "A"	180	235.1	18.7	1296.0	25.00	404.0	9.96	2.51
SCHMIDT "A"	160	239.4	18.9	1295.0	25.24	408.0	9.94	2.53
SCHMIDT "A"	140	243.8	19.5	1292.0	25.98	419.8	9.87	2.63
SCHMIDT "A"	120	248.0	21.0	1292.0	27.98	452.3	9.69	2.89

TABLE III.

SUMMARAY OF OBSERVED AND CALCULATED DATA. LOCOMOTIVE SCHENECTADY No.3.

DESIGNATION OF TEST: NUMBER	DESIGNATION OF TEST: LABORATORY SYMBOL	SPEED, MILES PER HOUR.	DRY COAL PER SQUARE FOOT OF GRATE SURFACE PER HOUR, POUNDS.	SMOKE-BOX TEMPERATURE, DEGREES F.	SUPERHEATING, DEGREES F.	EQUIVALENT EVAPORATION PER SQUARE FOOT OF HEATING SURFACE PER HOUR, POUNDS.	EQUIVALENT EVAPORATION PER POUND OF DRY COAL IN BOILER AND SUPERHEATER.	CUT OFF, PER CENT OF STROKE	MEAN EFFECTIVE PRESSURE POUNDS PER SQUARE INCH	INDICATED HORSE-POWER	POUNDS OF STEAM PER INDICATED HORSE-POWER HOUR	POUNDS OF COAL PER INDICATED HORSE-POWER HOUR	DRAW-BAR PULL, POUNDS	DRAW-BAR HORSE-POWER
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
1	30 – 2 – 200	30.3	48.2	558	187.0	6.08	10.40	17.87	41.42	290.2	21.30	2.82	2808	2269
2	30 – 4 – 200	30.1	62.1	622	222.9	7.79	10.38	31.35	61.47	438.1	17.88	2.41	4499	361.4
3	30 – 6 – 200	29.9	82.6	657	246.2	9.20	9.20	37.45	74.82	528.5	17.49	2.67	5702	452.8
4	30 – 4 – 160	30.0	46.5	579	201.6	6.01	10.70		44.90	317.2	19.56	2.50	3282	261.2
5	30 – 6 – 160	30.0	59.2	609	226.3	7.30	10.20		55.30	394.0	18.77	2.55	4165	334.3
6	30 – 8 – 160	30.0	74.4	610	245.4	8.88	9.86		69.06	490.7	18.38	2.58	5293	423.2
7	30 – 8 – 120	30.0	59.6	583	229.6	7.03	9.77	38.93	47.59	343.2	21.30	2.95	3845	308.8
8	30 – 10 – 120	30.0	65.0	584	243.9	8.24	9.74	44.13	59.37	419.7	20.14	2.64	4702	374.2
9	30 – 14 – 120	30.0	96.9	629	277.1	10.86	8.99	59.84	72.19	511.4	21.52	3.21	5856	469.7

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TABLE IV.

COMPARATIVE PERFORMANCE OF THE LOCOMOTIVE, ASSUMING IRREGULARITIES IN THE RESULTS OF INDIVIDUAL TESTS TO HAVE BEEN ELIMINATED.

DESIGNATION OF TESTS.		CORRECTED LOCOMOTIVE PERFORMANCE											
NUMBER	LABORATORY SYMBOL.	EQUIVALENT STEAM TO ENGINE PER HOUR FEED-WATER AT 60 DEGREES F.	EQUIVALENT EVAPORATION PER POUND OF DRY COAL BY EQUATIONS	DRY COAL FIRED PER HOUR. CORRECTED BY EQUATIONS.	DRY COAL PER INDICATED HORSE-POWER PER HOUR	EQUIVALENT STEAM PER INDICATED HORSE-POWER PER HOUR.	MACHINE FRICTION			DYNAMOMETER HORSE-POWER	DRAW-BAR PULL	COAL PER DYNAMOMETER HORSE-POWER PER HOUR	STEAM PER DYNAMOMETER HORSE-POWER PER HOUR.
							M.E.P.	HORSE-POWER	PER CENT INDICATED HORSE-POWER				
I	II	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV	XXVI	XXVII
1	30 2 200	8397	10.55	796	2.74	28.94	6.5	46.5	16.00	243.7	3017	3.27	34.45
2	30 4 200	10737	10.02	1072	2.44	24.50	8.5	60.2	13.70	377.9	4706	2.85	28.42
3	30 6 200	12817	9.52	1346	2.55	24.25	9.3	65.2	12.30	463.3	5840	2.90	27.67
4	30 4 160	8349	10.56	791	2.50	26.32	6.5	45.7	14.40	271.5	3415	2.92	30.75
5	30 6 160	10060	10.05	1002	2.55	26.91	8.5	60.2	15.30	333.8	4162	3.01	30.14
6	30 8 160	12372	9.64	1284	2.61	25.22	9.3	65.7	13.40	425.0	5320	3.02	29.12
7	30 8 120	9932	10.20	973	2.86	28.94	8.4	59.5	17.30	283.6	3533	3.43	35.02
8	30 10 120	11456	9.86	1162	2.77	27.30	6.9	48.5	11.70	371.2	4666	3.13	30.80
9	30 14 120	15183	9.02	1684	3.29	29.69	3.0	21.2	4.20	490.2	6112	3.43	30.98

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TABLE V.

STEAM PER INDICATED HORSE-POWER PER HOUR.

SUPERHEATER	BOILER PRESSURE POUNDS BY GAGE	SUPERHEAT DEGREES F	POUNDS STEAM PER INDICATED HORSE-POWER PER HOUR	B.T.U. PER INDICATED HORSE-POWER PER MINUTE
I	II	III	IV	V
SCHMIDT "A"	240	222.2	19.5	421.4
SCHMIDT "A"	220	226.5	19.0	410.7
SCHMIDT "A"	200	230.8	18.9	408.3
SCHMIDT "A"	180	235.1	18.7	404.0
SCHMIDT "A"	160	239.4	18.9	408.0
SCHMIDT "A"	140	243.8	19.5	419.8
SCHMIDT "A"	120	248.6	21.0	452.3
COLE "A"	240	139.7	22.6	474
COLE "A"	220	145.0	21.8	459
COLE "A"	200	150.3	21.6	455
COLE "A"	180	155.6	21.9	461
COLE "A"	160	160.8	22.3	468
COLE "A"	140	166.1	22.9	481
COLE "A"	120	171.4	23.8	497
COLE "B"	240	120.6	22.6	469
COLE "B"	220	126.8	22.1	460
COLE "B"	200	133.0	21.8	454
COLE "B"	180	139.2	22.1	460
COLE "B"	160	145.4	22.5	469
COLE "B"	140	151.5	23.0	479
COLE "B"	120	157.7	23.8	496
COLE "C"	240	109.9	22.7	469
COLE "C"	220	114.6	22.5	465
COLE "C"	200	119.4	22.6	467
COLE "C"	180	124.2	22.8	472
COLE "C"	160	128.9	23.5	486
COLE "C"	140	133.7	24.0	496
COLE "C"	120	138.4	24.8	512
NONE	240	0	24.7	483
NONE	220	0	25.1	491
NONE	200	0	25.5	498
NONE	180	0	26.0	507
NONE	160	0	26.6	517
NONE	140	0	27.7	537
NONE	120	0	29.1	563

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TABLE VI.

COAL CONSUMPTION UNDER DIFFERENT PRESSURES AND SUPERHEATERS.

BOILER PRESSURE POUNDS GAGE	POUNDS OF COAL PER INDICATED HORSE POWER PER HOUR				
	SATURATED STEAM	SUPERHEATER COLE "A"	SUPERHEATER COLE "B"	SUPERHEATER COLE "C"	SUPERHEATER SCHMIDT "A"
I	II	III	IV	V	VI
240	3.31	3.12	3.24	3.20	2.63
220	3.37	3.00	3.16	3.16	2.57
200	3.43	2.97	3.11	3.18	2.55
180	3.50	3.01	3.16	3.22	2.51
160	3.59	3.08	3.24	3.35	2.55
140	3.77	3.17	3.33	3.45	2.63
120	4.00	3.31	3.48	3.60	2.82

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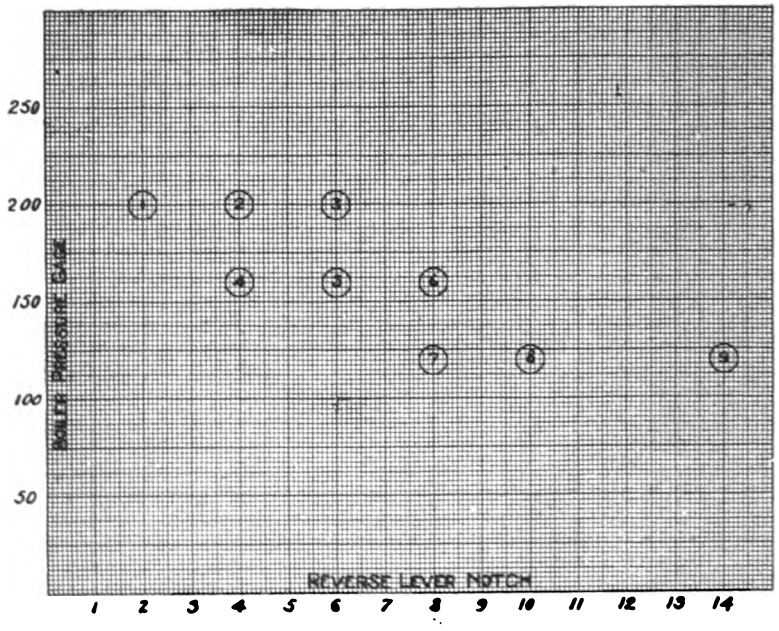


FIGURE 1.

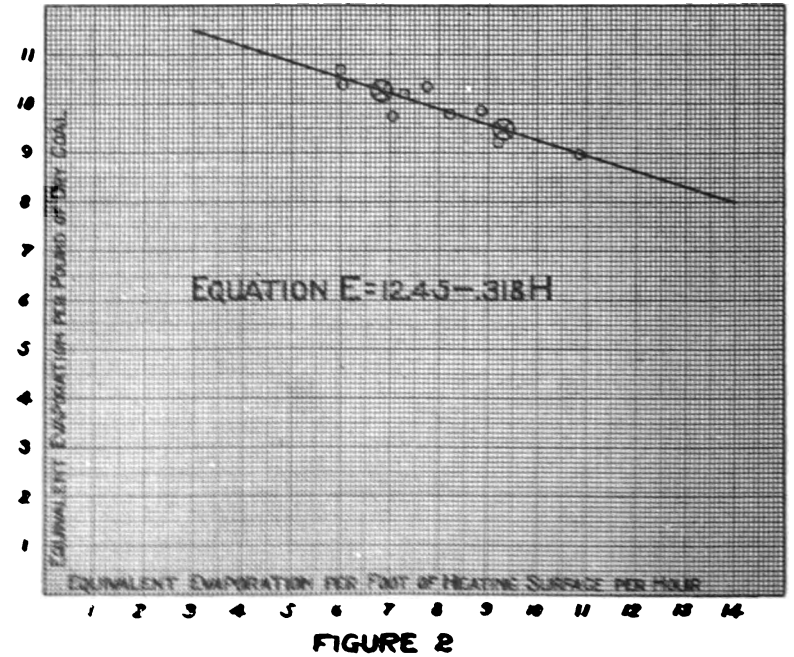


FIGURE 2

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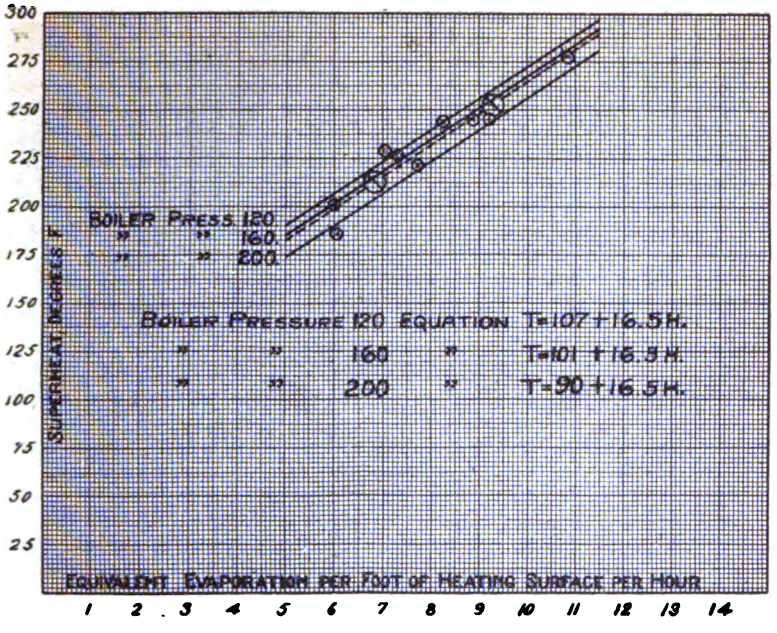


FIGURE 3.

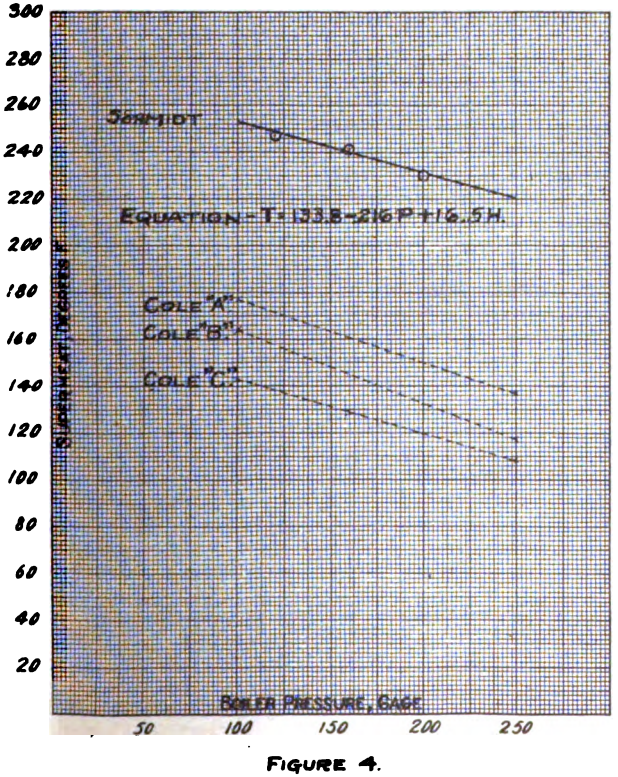


FIGURE 4.

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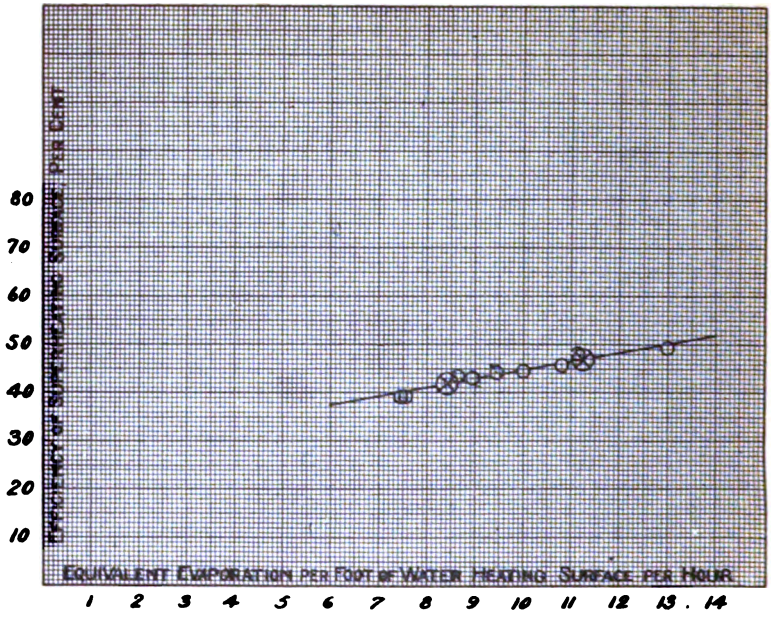


FIGURE 5.

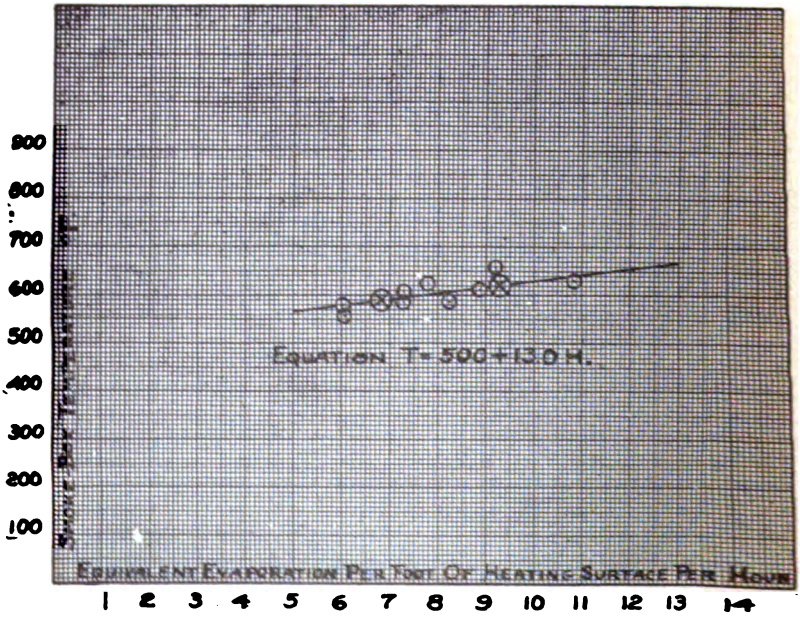


FIGURE 6.

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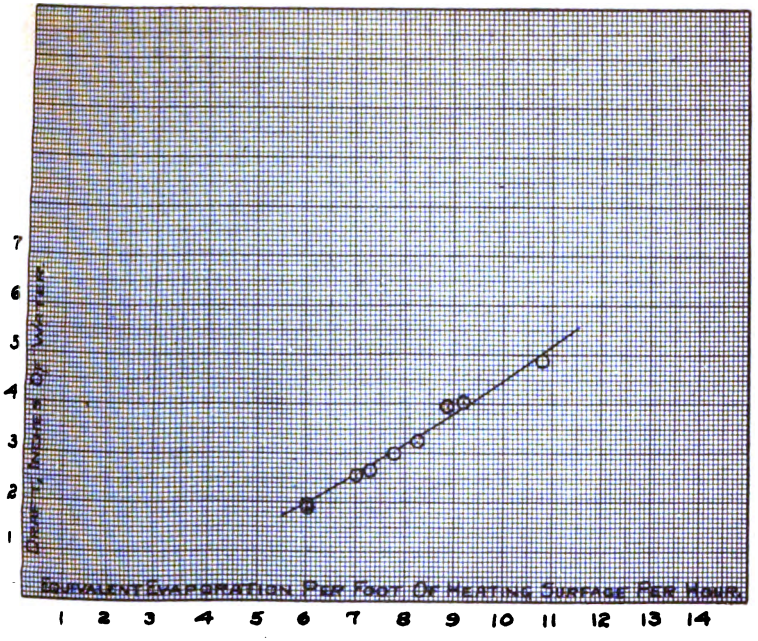


FIGURE 7.

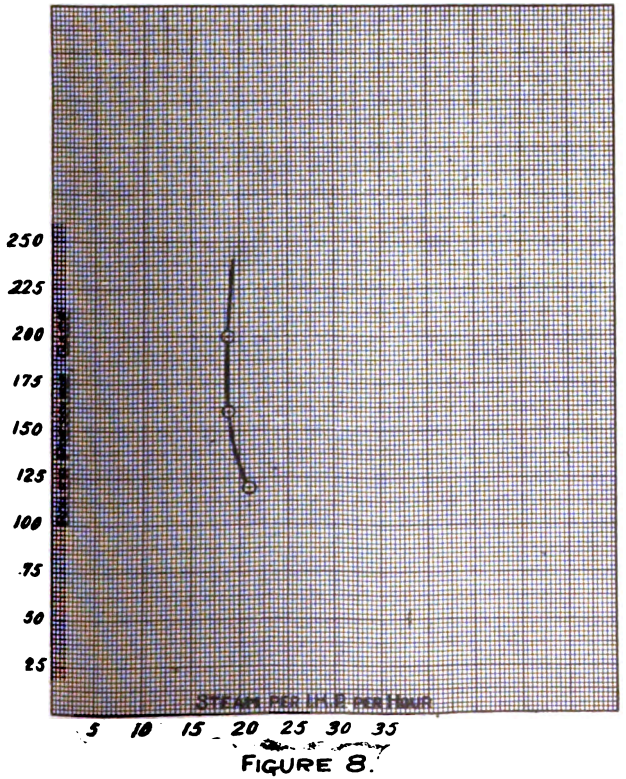


FIGURE 8.

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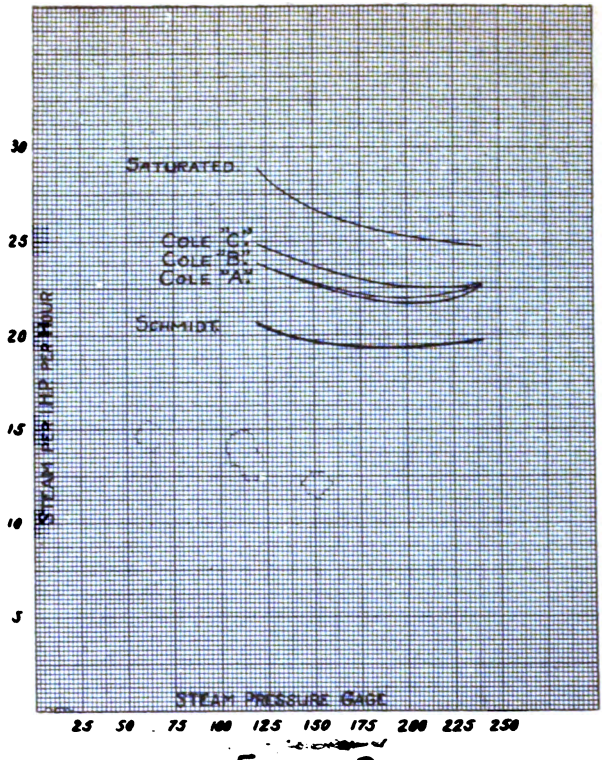


FIGURE 9.

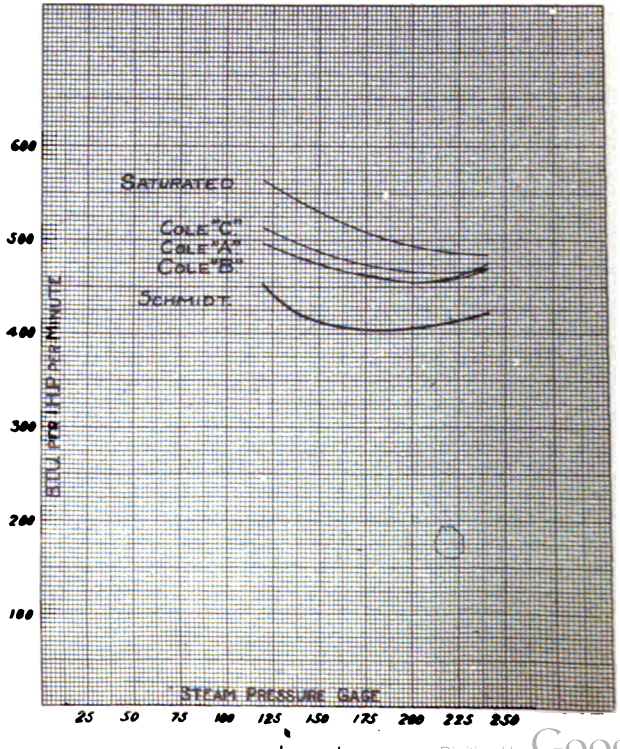


FIGURE 10

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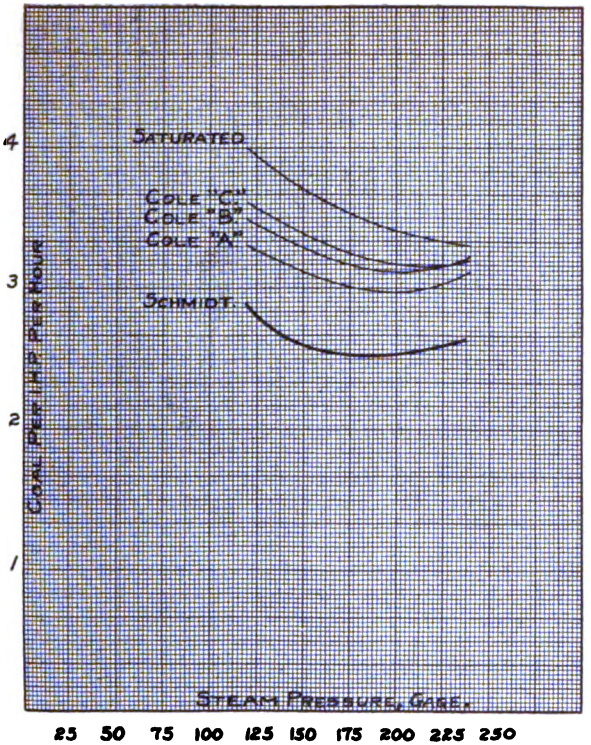


FIGURE 11.

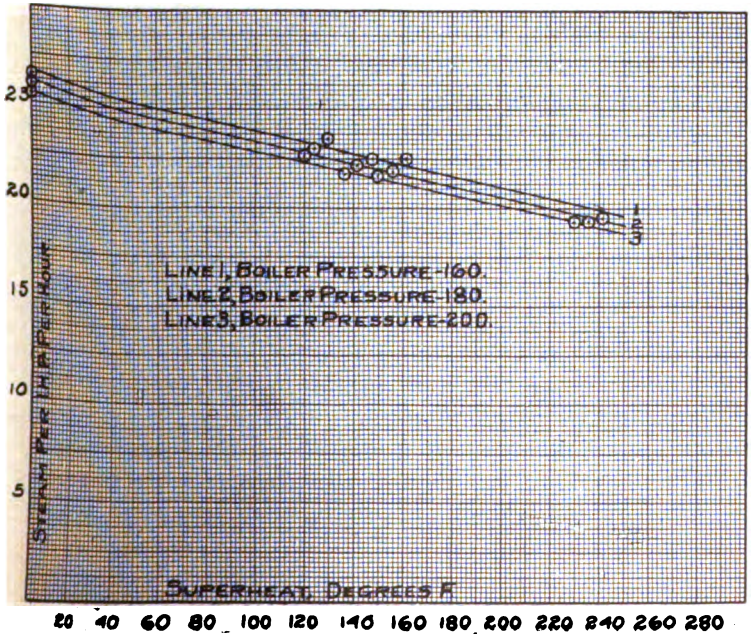


FIGURE 12.

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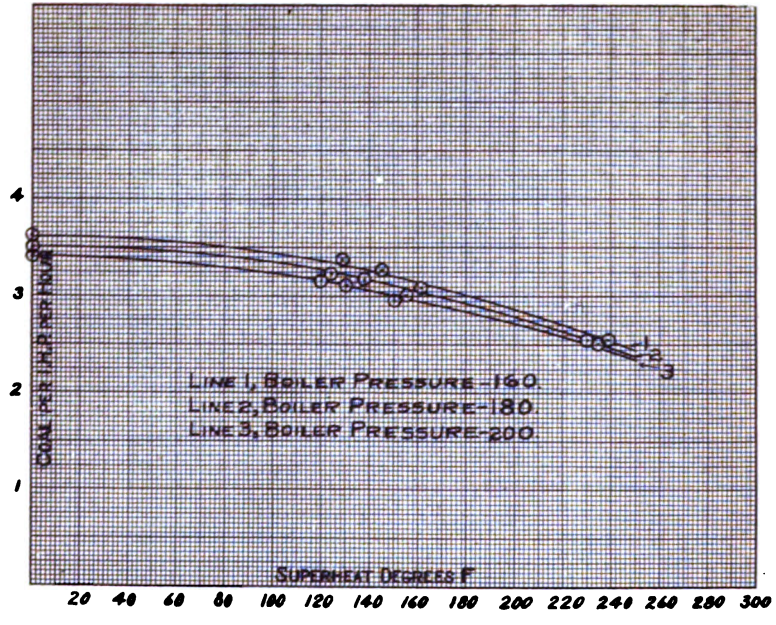


FIGURE 13.

THE PRESIDENT: The paper is received and open for discussion.

THE SECRETARY: Prof. Arthur Wood, of the Pennsylvania State College, a non-member, is here and has asked permission to discuss this paper. I would suggest that the privilege of the floor be extended to Professor Wood.

THE PRESIDENT: If there is no objection, Professor Wood may have the privileges of the floor.

PROF. ARTHUR WOOD: I thank you very much, Mr. Chairman, for the privilege extended to say a word in the discussion of this subject.

The first point of interest to me in this paper was also expressed last year to the effect that the second eighty degrees of superheat gave a greater saving than the first eighty degrees. I take it, a reason for that may be, in part, due to cylinder condensation. When you get near the saturation point, you may

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have some superheated steam and saturated steam in the cylinder at the same time. We do not always know how much moisture there is present at the end of expansion when we come down near the saturation point, so I am going to raise a question, as to whether or not it is fair to compare the economy of the first eighty degrees with the second eighty degrees or with the third eighty degrees of superheat.

Another point is that the net economy obtained, taking into account three factors, is not given. The first of these factors is the gain due to the superheat on the basis of the increased heat given to the superheat. The other two factors are negative. The first of the two is the loss due to the actual heat required to superheat. The second is the loss due to depreciation and the interest on the initial investment. If we take, for different degrees of superheat, the curve representing the increased economy, and then subtract for successive points the two factors mentioned, we find in the case of a steam turbine plant, that there is a point of net economy at about one hundred degrees superheat.

Now, if results on locomotive superheating could be put upon a basis such as that, where we could get the net economy by combining these three elements, I think we would have a very interesting result.

MR. H. H. VAUGHAN (Canadian Pacific Ry.): I am hardly in a position to discuss this paper very well. It contains a great deal that would require study before it could be intelligently discussed. However, those of you who have patiently listened to what I have said about superheating in the last few years must realize that this paper is quite a gratification to me. It explains very clearly several points that our experience with superheated locomotives induced us to bring forward, but which we were unable to substantiate without any actual scientific experiments. For instance, one or two years ago I ventured to state that in my opinion it was a waste of money and time to worry about equipping locomotives with superheaters that only gave a superheat of forty to eighty degrees. At that time such a course was advocated with the hope that applying the system in that way would avoid some condensation, and that results would be very nearly as good as they would be with high superheat.

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Professor Benjamin's paper shows us very distinctly why our experience was obtained, in practical service along these lines. The saving from low superheat is so small as not to make it worth while to maintain the apparatus.

You will remember that I stated that our feeling was that until we got up to 150 to 160 degrees, we hardly began to realize the benefits of superheating. From what I have heard in the last few months of the successful results obtained with locomotives equipped with still higher degrees of superheat, I feel that our position in keeping the temperatures at 550 to 580 degrees was too conservative — I think we would have gained very much more if we had followed the practice of the Schmidt people and worked with really high superheat. However, that is in the past; we no doubt want to make haste slowly, and we still have an opportunity open to us of getting higher superheat in the future.

A very interesting thing that strikes me in a cursory examination of this paper is a comparison of the diagrams Fig. 3 and Fig. 13. In Fig. 3 you will see that as the equivalent evaporation per square foot of heating surface goes up, the superheat goes up. Fig. 13 shows how we obtain more and more economy as the superheat goes up. There, gentlemen, is the explanation of the increased capacity that we get in actual service from superheater engines. We have always found that the harder you work them the more superheat you get, and the greater the saving, so that while perhaps your coal figures will only show a fifteen to twenty per cent saving, taking all the coal used, yet when you are working the engine hardest you are getting the most saving per horsepower. That is an increased advantage we have always found in superheaters, and while it has been frequently referred to it has never been so clearly shown as in this paper.

Another thing: when the last paper was presented covering the results at Purdue University two years ago I tried to make an explanation as to why we should find greater economy in service than the results at Purdue indicated. The amount of superheat we were using was about 180 to 190 degrees. There is quite a considerable drop in coal consumption between the amount of superheat obtained on the Cole superheater at Schenectady, and

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the one we were using, and it fairly well accounts for the results which we told you about.

I do not think that superheating needs any more advocacy on the part of the Canadian Pacific Railway. We think it is doing very well, and we have not changed our policy, except that we are going to follow the example set in the United States and equip our engines so that we will obtain a higher degree of superheat than has been obtained in the past.

MR. BENTLEY: It may be of interest to the members to know that we have just conducted a series of tests with superheaters and saturated steam engines, and that the results obtained compare very favorably with the results obtained on the testing plant. On our Chicago to Elroy run we had two superheated steam engines and two saturated steam engines, and in testing them there it was found that there was an average economy of twenty-five per cent in fuel consumed in favor of the superheated engine. This was not while the engine was standing still, or while being fired up in the roundhouse, but while the engine was in actual service.

As explained by Mr. Vaughan, the harder you work an engine equipped with a superheater the greater the economy. We found that very true. We made some tests on freight engines out in Iowa and we obtained practically the same results there. Our men feel that they have got the best engines they ever had in the superheated engines. The superintendent and everybody concerned can not say too much for them. As Mr. Pratt once said, everybody speaks well of the superheater engines, including the section man. [Laughter.]

We put two lubricators on those engines at first, one on each side, but had trouble with the left valve cutting out, so took the left lubricator off and put a larger one on in front of the engineer, on the right side, and then all the trouble was practically eliminated. I think any railroad man who has not had a superheater, and gets one, will be astonished at the results to be derived from it.

MR. C. D. YOUNG: Mr. Chairman and Gentlemen, I have not had time to read this paper, and it is pretty hard to grasp the full meaning of it offhand. There are, however, two questions that

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have come up in my mind concerning which I would like to have information. It is my understanding from the results of the test at Purdue, the conclusion was reached that it was preferable from the standpoint of economy to have steam pressure at from 160 to 170 pounds, that conclusion being based on the 80 and 160 degrees superheat.

Now referring to Fig. 13, giving the superheat in degrees per horse-power per hour, I notice that with the 240 degrees the lines 1, 2 and 3 are coming very close together, and I would judge if there were sufficient data for all of the intermediate points that probably line 3 and line 1 would intersect at about 280 degrees; in other words, as you increase the superheat effect, it looks as though you could run your boiler pressure up. That would seem to indicate that we could use the superheat to greater advantage than formerly, as was brought out by Professor Goss' paper, for the reason that it is very difficult to get larger cylinders on some of these engines. On the passenger engines it is very difficult to get much larger than a 27-inch cylinder. If we can hold down the size of the cylinder and can get the large economy that Professor Goss says was obtainable with 240 degrees of superheat, I feel that it is the preferable practice on our large locomotives.

I would like to ask Mr. Endsley, then, if in his opinion any change should be made in the original position taken — whether it is preferable to use 160 or 170 steam pressure for the boiler when using superheat.

Then another question is one respecting the temperature — with a boiler pressure of 200 degrees and a superheat of 240 degrees, you have a pretty high temperature in your superheat box, higher, I should judge, than the temperature in the smoke box. I would like to know whether there is any considerable drop in the superheater temperature from the header at the top until the steam reaches the valve chest?

MR. DEVOY: The Chicago, Milwaukee & St. Paul Railroad thought best to make a test to discover what we could expect from a superheater in our service. We have what we think is a pretty fair narrow fire box, ten-wheel type, piston valve — simple engine — and when I say that the engine was designed at our

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own shops, you will understand that it is a pretty fair engine. We were asked to take one of these engines equipped with a Schmidt superheater, and make a very extensive test with it.

While the test agrees very closely with this paper, still I want to give you what we obtained. We obtained about 200 degrees of superheat as an average for the entire test. The boiler pressure averaged about 177 pounds. The water rate was 21.54 per indicated horse-power. Now, I am giving you something that I do not believe is perhaps advisable, still I am going to tell you just exactly what we did obtain. Over the division, the average of our coal performance of the simple engine — the non-superheater engine — burned 18.4 pounds per hundred ton mile. The consumption in the case of the superheater engine showed that the average was 11.91 pounds, or a saving of thirty-five per cent in favor of the superheater. I want you to understand, though, that the engine equipped with the superheater was just out of the shop and in good condition, and the average was the division average of approximately 100 engines. So I would not say that that thirty-five per cent would bear out on the whole proposition. It is my opinion, without any reëquipping or rebuilding of a simple engine of that type, especially one in which the boiler capacity is somewhat limited, that you can reasonably expect to get a saving in fuel of at least twenty-five per cent.

Another very interesting feature shown by the dynamometer car which accompanies the test at all times was that we were able to haul from 150 to 300 tons more freight with the superheater engine than we were with the non-superheater engine, so I think the results obtained bear out the statements expressed in the Purdue University paper. Comparing the superheater with the average of other engines which show a thirty-five per cent saving, I think it is reasonable to expect that an economy of at least twenty-five per cent can be assured, and if you have an old engine in which the boiler is somewhat small, you can reasonably expect to get a little higher efficiency due to the fact that the action of the steam in the cylinder is somewhat different from that in the non-superheating engine. It appears that the engine holds her feet better, as we say, that is, she does not slip, and she hauls a load a little bit easier over the hills than the non-superheater engine.

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THE PRESIDENT: Professor Schmidt, do you care to say anything?

PROF. E. C. SCHMIDT: I have not had opportunity to study the paper enough to warrant my making specific comments, but I wish to express my appreciation of the work it stands for. It represents, I think, a most successful continuation of the excellent work which has been done at the Purdue University testing plant. It is interesting to see how well these laboratory tests confirm the results obtained in service, and which have been reported here and elsewhere during the past four or five years.

Mr. Young has pointed out a seeming inconsistency between the diagrams of this report and the conclusions previously reached that 180 pounds is the most economical boiler pressure. This conclusion, however, applies to locomotives using saturated steam, and, as I recall it, this question was not raised in the last year's report on the use of superheated steam.

THE PRESIDENT: I will ask Professor Endsley now to close the discussion.

PROF. L. E. ENDSLEY: I can answer Mr. Young's question by saying that in Dean Goss' report other things besides coal economy were taken into consideration, such as injector trouble and boiler maintenance. Reference to the report will show that the actual figures obtained from the first superheater, known as Cole "A," gave the least coal consumption at 200 pounds pressure. This same pressure gave the lowest coal consumption for the lower degrees of superheat, namely, those obtained from Cole superheaters "B" and "C." In the work reported this year, under a high degree of superheat the same coal consumption was obtained at 160 and 200 pounds boiler pressure. I do not think, therefore, that it makes any difference from the standpoint of efficiency whether a locomotive is run at 160 or 200 pounds pressure with this high degree of superheat. I might say that as yet we have not taken up the question of increased power due to superheat. We are planning to do this next year. What we have attempted to do so far is to run under different degrees of superheat with the same power, as nearly as we could get it, so that the saving in coal and water consumption as shown in this paper repre-

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sents the saving obtained while the locomotive was doing approximately the same amount of work. I think it will be possible with this high degree of superheat to increase the power of the locomotive twenty-five per cent. In this year's report it will be seen that the maximum amount of dry coal burned per square foot of grate per hour was 96.9 pounds, which is very low for this kind of a locomotive, which has a narrow fire box. There is no doubt but that we can increase this to 125 pounds per square foot of grate or even more.

As to Professor Wood's comment, I will say that we have not in any way taken up the maintenance of the boiler or the other things which are necessary when figuring the exact efficiency. We have simply compared the coal used per indicated horsepower — that is all. The work which could be done along the line to which Professor Wood refers will no doubt be carried on by some of the railroads, when they can figure out the difference in cost for maintaining the superheater; but that is a question which the laboratory is not able to take care of, because we have only one engine, our repairs are not very numerous, and we have no method of keeping track of the cost of repairs in our shop.

THE PRESIDENT: The next subject, gentlemen, is on safety valves. As the committee on safety valves only rendered the report since we have been in Atlantic City, it is referred to the incoming Executive Committee.

If there is nothing else on the docket to-day, we will adjourn.

Adjourned.

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FRIDAY SESSION.

THE PRESIDENT: Gentlemen, if you will kindly come to order we will proceed with the work of the meeting. The Secretary will first make some announcements.

THE SECRETARY: I have the report of the Auditing Committee, Mr. President, as follows:

We, the Auditing Committee, have examined and compared the books and vouchers of the Secretary and Treasurer, and find the same to be correct.

Respectfully submitted,
(Signed) C. H. RAE,
M. J. MCCARTHY,
J. W. FOGG,
Committee.

THE PRESIDENT: Gentlemen, you have heard the report of the Auditing Committee. What is your pleasure in regard to it?

MR. SELEY: I move that it be approved.

MR. YOUNG: I second the motion.

THE PRESIDENT: It has been moved and seconded that the report of the Auditing Committee be approved. All in favor will signify the same by saying aye; those to the contrary, no. Carried. It is so ordered.

The first order of business is the report of the Committee on Safety Appliances, by Mr. Theo. H. Curtis, Chairman of the Committee.

Mr. Curtis then presented the report as follows:

REPORT OF THE COMMITTEE ON SAFETY APPLIANCES.

To the Members:

Your Committee on Safety Appliances has carefully considered this important subject in the limited amount of time that it has had since the issuance of the order of the Interstate Commerce Commission in the matter of United States Safety Appliance Standards, dated March 13, 1911, which is a modification of the original order issued October 13, 1910.

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The United States Safety Appliance Standards prescribed in the Interstate Commerce Commission's order of March 13, 1911, must be applied to all equipment built on or after July 1, 1911.

As to applying the United States Safety Appliance Standards prescribed in the Interstate Commerce Commission's order of March 13, 1911, to equipment built prior to July 1, 1911, the order of the Commission prescribes the following:

Carriers are granted an extension of one year from July 1, 1911, to change switching locomotives to comply with the standards prescribed in said order.

Carriers are granted an extension of two years from July 1, 1911, to change all locomotives of other classes to comply with the standards prescribed in said order.

This order prescribes the following standards:

STEAM LOCOMOTIVES IN ROAD SERVICE.

Tender Sill-steps.

Number.— Four (4) on tender.

Dimensions.— Bottom tread not less than eight (8) by twelve (12) inches, metal.

(May have wooden treads.)

If stirrup-steps are used, clear length of tread shall be not less than ten (10), preferably twelve (12), inches.

Location.— One (1) near each corner of tender on sides.

Manner of Application.— Tender sill-steps shall be securely fastened with bolts or rivets.

Pilot Sill-steps.

Number.— Two (2).

Dimensions.— Tread not less than eight (8) inches in width by ten (10) inches in length, metal.

(May have wooden treads.)

Location.— One (1) on or near each end of buffer-beam outside of rail and not more than sixteen (16) inches above rail.

Manner of Application.— Pilot sill-steps shall be securely fastened with bolts or rivets.

Pilot-beam Handholds.

Number.— Two (2).

Dimensions.— Minimum diameter, five-eighths (5/8) of an inch, wrought iron or steel.

Minimum clear length, fourteen (14), preferably sixteen (16), inches.

Minimum clearance, two and one-half (2½) inches.

Location.— One (1) on each end of buffer-beam.

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(If uncoupling-lever extends across front end of locomotive to within eight (8) inches of end of buffer-beam, and is seven-eighths (⅞) of an inch or more in diameter, securely fastened, with a clearance of two and one-half (2½) inches, it is a handhold.)

Manner of Application.— Pilot-beam handholds shall be securely fastened with bolts or rivets.

SIDE-HANDHOLDS.

Number.— Six (6).

Dimensions.— Minimum diameter, if horizontal, five-eighths (⅝) of an inch; if vertical, seven-eighths (⅞) of an inch, wrought iron or steel.

Horizontal, minimum clear length, sixteen (16) inches.

Vertical, clear length equal to approximately height of tank.

Minimum clearance two (2), preferably two and one-half (2½), inches.

Location.— Horizontal or vertical: If vertical, one (1) on each side of tender within six (6) inches of rear or on corner; if horizontal, one (1) near each end on each side of tender, not less than twenty-four (24) nor more than thirty (30) inches above center line of coupler; clearance of outer end of handhold shall be not more than eight (8) inches from end of tender.

One (1) on each side of tender near gangway; one (1) on each side of locomotive at gangway; applied vertically.

Manner of Application.— Side handholds shall be securely fastened with not less than one-half (½) inch bolts or rivets.

REAR-END HANDHOLDS.

Number.— Two (2).

Dimensions.— Minimum diameter, five-eighths (⅝) of an inch, wrought iron or steel.

Minimum clear length; fourteen (14) inches.

Minimum clearance, two (2), preferably two and one-half (2½), inches.

Location.— Horizontal: One (1) near each side of rear end of tender on face of end-sill. Clearance of outer end of handhold shall be not more than sixteen (16) inches from side of tender.

Manner of Application.— Rear-end handholds shall be securely fastened with not less than one-half (½) inch bolts or rivets.

UNCOUPLING-LEVERS.

Number.— Two (2) double levers, operative from either side.

Dimensions.— Rear-end levers shall extend across end of tender with handles not more than twelve (12), preferably nine (9), inches from side of tender with a guard bent on handle to give not less than two (2) inches clearance around handle.

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Location.— One (1) on rear end of tender and one (1) on front end of locomotive.

Handles of front-end levers shall be not more than twelve (12), preferably nine (9), inches from ends of buffer-beam, and shall be so constructed as to give a minimum clearance of two (2) inches around handle.

Manner of Application.— Uncoupling-levers shall be securely fastened with bolts or rivets.

COUPLERS.

Locomotives shall be equipped with automatic couplers at rear of tender and front of locomotive.

STEAM LOCOMOTIVES USED IN SWITCHING SERVICE.

FOOTBOARDS.

Number.— Two (2) or more.

Dimensions.— Minimum width of tread, ten (10) inches, wood.

Minimum thickness of tread, one and one-half (1½), preferably two (2), inches.

Minimum height of back-stop, four (4) inches above tread.

Height from top of rail to top of tread, not more than twelve (12) nor less than nine (9) inches.

Location.— Ends or sides.

If on ends, they shall extend not less than eighteen (18) inches outside of gauge of straight track and shall be not more than twelve (12) inches shorter than buffer-beam at each end.

Manner of Application.— End footboards may be constructed in two (2) sections, provided that practically all space on each side of coupler is filled; each section shall be not less than three (3) feet in length.

Footboards shall be securely bolted to two (2) one (1) by four (4) inches metal brackets, provided footboard is not cut or notched at any point.

If footboard is cut or notched or in two (2) sections, not less than four (4) one (1) by three (3) inches metal brackets shall be used, two (2) located on each side of coupler. Each bracket shall be securely bolted to buffer-beam, end-sill or tank-frame by not less than two (2) seven-eighths (⅞) inch bolts.

If side footboards are used, a substantial handhold or rail shall be applied not less than thirty (30) inches nor more than sixty (60) inches above tread of footboard.

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SILL-STEPS.

Number.— Two (2) or more.

Dimensions.— Lower tread of step shall be not less than eight (8) by twelve (12) inches, metal. (May have wooden treads.)

If stirrup-steps are used, clear length of tread shall be not less than ten (10), preferably twelve (12), inches.

Location.— One (1) or more on each side at gangway secured to locomotive or tender.

Manner of Application.— Sill-steps shall be securely fastened with bolts or rivets.

END-HANDHOLDS.

Number.— Two (2).

Dimensions.— Minimum diameter, one (1) inch, wrought iron or steel.

Minimum clearance, four (4) inches, except at coupler casting or braces, when minimum clearance shall be two (2) inches.

Location.— One (1) on pilot buffer-beam; one on rear end of tender, extending across front end of locomotive and rear end of tender. Ends of handholds shall be not more than six (6) inches from ends of buffer-beam or end-sill, securely fastened at ends.

Manner of Application.— End handholds shall be securely fastened with bolts or rivets.

SIDE HANDHOLDS.

Number.— Four (4).

Dimensions.— Minimum diameter, seven-eighths (⅞) of an inch, wrought iron or steel.

Clear length equal to approximate height of tank.

Minimum clearance, two (2), preferably two and one-half (2½), inches.

Location.— Vertical. One (1) on each side of tender near front corner; one (1) on each side of locomotive at gangway.

Manner of Application.— Side handholds shall be securely fastened with bolts or rivets.

UNCOUPLING-LEVERS.

Number.— Two (2) double levers, operative from either side.

Dimensions.— Handles of front-end levers shall be not more than twelve (12), preferably nine (9), inches from ends of buffer-beam, and shall be so constructed as to give a minimum clearance of two (2) inches around handle.

Rear-end levers shall extend across end of tender with handles not

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more than twelve (12), preferably nine (9), inches from side of tender, with a guard bent on handle to give not less than two (2) inches clearance around handle.

Location.— One (1) on rear end of tender and one (1) on front end of locomotive.

Handrails and Steps for Headlights.

Switching locomotives with sloping tenders with manhole or headlight located on sloping portion of tender shall be equipped with secure steps and handrail or with platform and handrail leading to such manhole or headlight.

End Clearance.

No part of locomotive or tender except draft-rigging, coupler and attachments, safety-chains, buffer-block, foot-board, brake-pipe, signal-pipe, steam-heat pipe or arms of uncoupling lever shall extend to within fourteen (14) inches of a vertical plane passing through the inside face of knuckle when closed with horn of coupler against buffer-block or end-sill.

Couplers.

Locomotives shall be equipped with automatic couplers at rear of tender and front of locomotive.

SPECIFICATIONS COMMON TO ALL STEAM LOCOMOTIVES.

Hand-brakes.

Hand-brakes will not be required on locomotives nor on tenders when attached to locomotives.

If tenders are detached from locomotives and used in special service, they shall be equipped with efficient hand-brakes.

Running-boards.

Number.— Two (2).

Dimensions.— Not less than ten (10) inches wide. If of wood, not less than one and one-half (1½) inches in thickness; if of metal, not less than three-sixteenths (3/16) of an inch, properly supported.

Location.— One (1) on each side of boiler extending from cab to front end near pilot-beam. (Running-boards may be in sections. Flat-top steam-chests may form section of running-board.

Manner of Application.— Running-boards shall be securely fastened with bolts, rivets or studs.

Locomotives having Wooten type boilers with cab located on top of boiler more than twelve (12) inches forward from boiler-head shall have

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suitable running-boards running from cab to rear of locomotive, with hand-railings not less than twenty (20) nor more than forty-eight (48) inches above outside edge of running-boards, securely fastened with bolts, rivets or studs.

HANDRAILS.

Number.— Two (2) or more.

Dimensions.— Not less than one (1) inch in diameter, wrought iron or steel.

Location.— One on each side of boiler extending from near cab to near front end of boiler, and extending across front end of boiler, not less than twenty-four (24) nor more than sixty-six (66) inches above running-board.

Manner of Application.— Handrails shall be securely fastened to boiler.

TENDERS OF VANDERBILT TYPE.

Tenders known as the Vanderbilt type shall be equipped with running-boards; one (1) on each side of tender not less than ten (10) inches in width and one (1) on top of tender not less than forty-eight (48) inches in width, extending from coal space to rear of tender.

There shall be a handrail on each side of top running-board, extending from coal space to rear of tank, not less than one (1) inch in diameter and not less than twenty (20) inches in height above running-board from coal space to manhole.

There shall be a handrail extending from coal space to within twelve (12) inches of rear of tank, attached to each side of tank above side running-board, not less than thirty (30) nor more than sixty-six (66) inches above running-board.

There shall be one (1) vertical end handhold on each side of Vanderbilt type of tender, located within eight (8) inches of rear of tank extending from within eight (8) inches of top of end-sill to within eight (8) inches of side hand-rail. Post supporting rear end of side running-board if not more than two (2) inches in diameter and properly located, may form section of handhold.

An additional horizontal end handhold shall be applied on rear end of all Vanderbilt type of tenders which are not equipped with vestibules. Handhold to be located not less than thirty (30) nor more than sixty-six (66) inches above top of end-sill. Clear length of handhold to be not less than forty-eight (48) inches.

Ladders shall be applied at forward ends of side running-boards.

HANDRAILS AND STEPS FOR HEADLIGHTS.

Locomotives having headlights which can not be safely and conveniently reached from pilot-beam or steam-chests shall be equipped with

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secure handrails and steps suitable for the use of men in getting to and from such headlights.

A suitable metal end or side ladders shall be applied to all tanks more than forty-eight (48) inches in height, measured from the top of end-sill, and securely fastened with bolts or rivets.

COUPLERS.

Locomotives shall be equipped with automatic couplers at rear of tender and front of locomotive.

To provide for the usual inaccuracies of manufacturing and for wear, where sizes of metal are specified, a total variation of five (5) per cent below size given is permitted.

The matter of appending to this report, drawings or cuts showing the manner of application of these safety appliances was considered by your committee, but owing to the various local conditions and practices to be met by the various railroads of the country in applying these standards and also to the limited amount of time in which to gather the requisite information since the issuance of the final order of the Interstate Commerce Commission, your committee has not prepared drawings or cuts.

Respectfully submitted,

THEO. H. CURTIS,
M. K. BARNUM,
C. B. YOUNG,
Committee.

LOUISVILLE, KY., May 22, 1911.

MR. CURTIS: I wish to make a few remarks about this report. Referring to page 2 under the heading "Pilot Sill-steps — location — one (1) on or near each end of buffer beam outside of rail and not more than sixteen (16) inches above rail." There have been a great many questions asked as to where the railroads are going to place this sill step. The order is very plain that it must be outside of the rail, and not over 16 inches above the rail. It may be placed on the face of the bumper beam, or it may be placed on the rear of the bumper beam, or it may be placed on the pilot; so long as it is outside of the rail and not over sixteen inches above the rail, it complies with the law.

There are some railroads that use this step entirely, where the clearance will permit it, on the rear of the bumper beam. Other railroads use it and have the same attached to the pilot. Some railroads are applying it on the face of the bumper beam. I wish

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to call your attention to the fact that this step is to have a metal tread 8 by 10 inches. It says it also may have a wooden tread. My interpretation of this is that sill step must have a metal tread. If you wish to put a wooden tread on top of it you can.

In regard to handholds, on page 2, under "Pilot Beam Handholds," and page 3 under "Rear-end Handholds," for steam locomotives in road service the handhold shall be ⅝ inch in diameter minimum clear length 14 inches, preferably 16 inches, and minimum clearance 2½ inches. On page 3 the same handhold is prescribed for the rear end.

Turning to page 4, steam locomotives used in switching service, the end handhold must be 1 inch in diameter, with 4-inch clearance, except at coupler casting or braces, when minimum clearance shall be 2 inches.

Under the location we learn that this handhold shall extend across the front end of the locomotive, in the rear of the tender. You will note that the road engine has a different handhold from the switch engine. There is nothing said in the order as to when the road engine becomes a switch engine, but it is reasonable to understand that a road engine could not switch too long and not become a switch engine; therefore it becomes almost necessary to equip your road engine as a switch engine in order that you may transfer a road engine to switch-engine service. The handholds on a switch engine would be permissible on a road engine, but the handholds on a road engine would not be permissible on a switch engine.

Now turn to page 5 under the heading "End-ladder Clearance," the word "ladder" should be omitted. It is end clearance. The important feature of this requirement is the 14 inches from the vertical plane passing through the inside face of knuckle when closed with horn of coupler against buffer block or end sill. There are exemptions made for air holes, steam holes and different appliances, but there are no exemptions made for bolt heads, rivets or push-pole pockets. Therefore the matter stands about like this: There are 14 inches required by law; about half an inch will have to be added for contingencies, 3 inches will need to be added for push-pole pockets and other parts of the tender that are not exempt, and 2 to 3 inches clearance must be added for compres-

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sion of the spring; making a total distance of about 20½ inches from the end sill to the inside face of the knuckle. Now, this is a very long overhang to maintain on a switch engine. Especially is this so when it is required on a switch engine, and a road engine may be made a switch engine almost momentarily. So it becomes practically necessary to equip a road engine with a very long distance between the knuckle and the end sill. With this long overhang, or distance, we begin to have some more trouble. The uncoupling lever arm will be very long. It may be 15 to 18 inches long. In fact, it is so long that it is very hard to lift the knuckle. This uncoupling apparatus must extend near the full width of the tender; there is very little allowance left. There is nothing said in the law as to the length of the arm on the outer end of the uncoupling lever as it applies to locomotives, but there is as applied to cars. It is open to reasonable interpretation that this lever must not be too long. If it is too long, when the trainman on one side of the tender or pilot raises the uncoupling lever the long handle will stick out on the other side and perhaps injure a fellow trainman.

These difficulties must needs be obviated after a very careful study of this safety appliance question and after, I might say, a conference of your best men in an endeavor to ascertain how it can be applied to your locomotives. I have held several of these conferences with the officials of the road with which I am connected, and we feel that we have learned a great deal about the application of safety appliances, but we believe there is still much more to learn.

On page 7 the committee refers to drawings. They considered submitting drawings, but as the locomotives are not applied in interchange, and the matter of the application of these appliances to locomotives may be considered as a local matter the committee thought it better to leave this subject open for another year, and rest it to your discretion whether or not there should be drawings submitted.

THE PRESIDENT: Gentlemen, you have heard the report of the Committee on Safety Appliances. If there is no objection it will be received, and it is now open for discussion.

I would like to ask the chairman of this committee if on page 5,

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under "Side Handholds," in the line "manner of application," if the word "end" should not be "side?"

MR. CURTIS: Yes, that should be side. I will say for your information that the order of the Interstate Commerce Commission combines the locomotive and car, and your committee endeavored to separate the two orders as they applied respectively to locomotives and to cars, and these little errors may have crept in in that way.

THE PRESIDENT: Discussion is in order. This is another interesting subject, and if there is anything about it that is not clearly understood, now is the time to obtain information.

An important feature in connection with this subject is the length of the drawbar head to obtain the 14-inch clearance, especially on the rear of the tender, where the Standard M. C. B. coupler has been used. I believe we should have some light as to how we are going to handle this particular question. We will either have to lengthen out the head or we will have to move out the drawbar and draft rigging, and I think we should arrive at an understanding as to the best method of taking care of this clearance with as few couplers as possible. In interchange work this question does not enter, but there would seem to be no necessity for perpetuating a dozen styles of couplers if two or three will answer the purpose. Mr. Dunham, you are on the Committee on Standards of the Master Car Builders' Association — what is your opinion on this matter?

MR. DUNHAM: The Committee on Standards of the Master Car Builders' Association had this matter under consideration. They were informed that the Special Coupler Committee of the Master Car Builders' Association was figuring on a longer head to take care of this clearance. If there is any member of that committee in the room, he might give more accurate information than I can.

THE PRESIDENT: Is there a member of the Special M. C. B. Coupler Committee here?

MR. WILDIN: That is a fact — that is what the Coupler Committee will report at the Master Car Builders' Association meeting next week, and it strikes me that whatever action is taken

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by that Association will apply, so far as the length of the coupler is concerned, to the switching locomotive as well as the cars. The only thing that is troubling the committee is to get some idea as to how many standards will be necessary. We have not been able to get the information from the various roads as to their clearances. Until we do have this information we shall be unable to sum up and say how many standards there will necessarily be.

MR. SELEY: Speaking in a utilitarian sense, in regard to fitting up of our equipments to meet these requirements, my thought is that the switch engines should be considered first, for the reason we must have them equipped within a year, to comply with the law; and then comes about the idea that road engines are used in switching service very extensively, and while we have two years on them, we ought not to neglect the thought that possibly switch engines and road engines should have the same equipment. I am referring to the end handholds particularly.

Probably what we shall do will be to put stands on the buffer beams 6 inches high, to receive pipe handhold pinned to these stands, with an opening in the center for the uncoupling arm, and have the uncoupling lever inside the pipe. It makes a very neat arrangement. So far as I can construe the law it will fulfil the requirement. It is applicable both to switch and road engines, and so far as we had the thing figured out when I came away, that is about where it will land if we do not change our mind.

The fitting up of road engines so as not to make a violation under the heading which is used in these rules, which reads " engines used in switching service," is pretty broad, and I do not know whether we could plead temporary as a bar or not, so I think it is very important, indeed, that the road engines be fitted up on the switch engine lines in so far as handholds and clearances are concerned. We have found considerable advantage in our design of front ends of switchers on account of having a tapered buffer beam, that is, a bowed front, which gives us better clearance out where the man stands in relation to the coupler lengths than where you have a straight design.

THE PRESIDENT: Is there any further discussion on this subject?

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MR. J. H. MANNING (D. & H. Co.): I think it would be a serious mistake on the part of this association to introduce another M. C. B. coupler to take care of the end clearance on locomotives or cars. There is no doubt but that the yoke can be lengthened out and a fillet put in to meet all requirements. We do it now. Where the springs are used or friction gear, the yoke can be lengthened, and where the niggerhead is fastened onto the back of the end sill, a liner can be put behind it.

I do not think that what we do with that matter will have much practical effect, as far as the locomotive end is concerned. The chances are that each road will adopt its own ideas in complying with the law. I presume the Committee on Standards of the Master Car Builders' Association will have something to say as to how to meet the conditions on the cars.

MR. SELEY: I might have added it is our intention in a number of designs to put in a filler and lengthen out in that way.

THE PRESIDENT: Mr. Manchester, may we hear from you on this subject?

MR. MANCHESTER: I am here to-day to listen to this subject.

THE PRESIDENT: That seems to be the trouble. We are all here to listen, apparently, but we would like to have some of you gentlemen give some ideas in regard to this matter. Mr. Cromwell, what is your opinion of the subject under consideration?

MR. CROMWELL: I was not in the room when the report was read, and have not quite gotten through reading it; however, I believe it is desirable to keep down the number of couplers which are used on our wooden tender frames. I do not see how it is going to be possible to use our M. C. B. type coupler without entirely cutting away the end sills, because you will have to move out the coupler to give you end-ladder clearance. You can take care of it on a steel underframe, but when you come to a wooden one you will not be able to solve it in that way. I am afraid we will have to look toward using a longer shank, but the drawbars will not have sufficient support to hold up the coupler unless you move out the carrier iron with the head of the coupler. I did not realize it would require quite so much overhang as has been demonstrated by the chairman. We can take care of this part on the

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new locomotives, of course, but the older ones are the ones which will give us trouble.

I would like to add to the remarks of Mr. Seley that it would be of great importance to fit out both the freight and the switcher locomotive tenders in the same way, because they get into the same service. I believe we are all here willing to listen to suggestions on this matter, because we have not as yet had sufficient time to solve the problem. I believe it would be well if the subject were thoroughly threshed out on the floor.

MR. CURTIS: In regard to the coupler, whether the head shall be made longer or the shanks shall be made longer, I have had considerable experience so far in this matter. We have endeavored to keep the switch engine with the M. C. B. coupler, with the 9-inch head, that is 9 inches from the coupler horn to the inside face of the knuckle. It required 8½ inches in the buffer block to hold the coupler up. We had to cut the end sill nearly in two to get the yoke of the coupler to come up far enough to allow any action of the spring; and when we looked upon our work we were not satisfied with it; it did not look well. Then we purchased a coupler that had a head 13½ inches from the coupler horn to the inside face of the knuckle. It is the cheapest way to handle the subject. This head was placed in the tender without any change whatever, except removing the old M. C. B. coupler and applying a new coupler without name. This coupler looks bad; the overhang is immense to a man that is accustomed to a close coupled engine, but of the two I think the change of the coupler is by far the better. I take this view from the experience I have had in having equipped engines both ways.

MR. CHAMBERS: With reference to the push-pole pocket, I would say that there is a way of getting around that, namely, the pocket may be depressed so that it will be flush with the sill. On wooden end sills we have fitted up a few that were depressed and have put in simply a steel plate, forming a pocket in it virtually only ⅝ of an inch outside of the face of the sill.

We took up the matter directly with the Interstate Commerce Commission about the curve line of the uncoupling handle, which stuck out, say, four inches. They passed upon that as not being a matter considered in the Act, but that it was taken in the excep-

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tion that was made with respect to the coupling lever arm. We had a cast iron push-pole pocket on the same end sill that did not stick out as far as this coupler handle did, but I did not bring that before the Commission; I thought I would wait a little while, as I did not care to take it up with them, although I could not see what difference it made when it was outside of the handle and both were outside of the step on the rear. My idea was that they would not accept that as an exception. But, as I have said, we have depressed the end sill by countersinking a push-pole pocket in it, and that will do away with possibly 3½ to 4 inches of that overhang, and it is the overhang, as mentioned by Mr. Seley, that would be decidedly objectionable.

THE PRESIDENT: Gentlemen, if you are not all familiar with the requirements of the law on the subject now is the time to ask questions.

MR. SELEY: With regard to asking questions as the President has suggested, I would like to say this: The special committee which has had to do with the handling of these matters to a considerable extent, and also the conference committee, composed of members of this Association, have been discharged in so far as any connection with the legislation end of the matter is concerned. It is now up to this Association, as you probably noticed in the President's address, to take care of the details. I do not know how the Executive Committee can handle that matter, but I can see how members can make it pretty hard for the fellows who are on that committee to interpret the law. Would suggest trying to interpret the law for yourselves; do not ask somebody else to do it. I happen to know that a number of railroads have sent in drawings of their cars asking: Does this comply with the law? Now these are very difficult questions to answer, on account of the time that it takes to analyze the drawing. I hope our membership will realize the burden that has been put, and possibly may be continued, on any one who has had to do with handling matters of this kind, and lighten it as much as possible by not asking such general questions. We have to a certain extent got to interpret these things ourselves. It is difficult to get any definite interpretation from the Interstate Commerce Commission on many of these things. The matter of drawings I do not think will ever com-

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pletely solve the question, because our cars differ so much. These rules are for general interpretation and we are to apply them to each of our particular designs. In this matter I believe every fellow has got, as it were, to work out his own salvation.

MR. DUNHAM: In connection with this 8 by 10 size of step I would inquire whether the long dimension refers to the shape of the step crosswise of the track or lengthwise of the track?

MR. CURTIS: The step can be put on either way so long as it is 8 by 10.

MR. F. H. SHEFFER (N. C. & St. L. Ry.): I would like to inquire whether this ladder shall be placed on the right side or on the left side?

MR. CURTIS: It may be placed anywhere on the rear of the tender. At the conference with the inspectors at Washington that matter was discussed and it was thought preferable to have it at the side of the tender, so that it would not interfere with a man going up the ladder when the tender was coupled to a car that had a vestibule.

THE PRESIDENT: If there is no further discussion of this subject I will ask Mr. Curtis if he has anything to say in closing?

MR. CURTIS: I have nothing further to say that I think of, although I will be glad to answer any questions that may be asked if I can.

I will state that a tender does not require a hand brake when coupled to a locomotive, but if you ship that tender in a train then it will be necessary to put a hand brake on it as it then becomes a car.

You will notice that a variation of five per cent is allowed for manufacture and wear. This must not be taken as a permission to reduce the size of the material when applied, to the minimum. That is, when it calls for a $\frac{5}{8}$ handhole, bar iron nominally $\frac{5}{8}$ in diameter could be used. You should not use a bar, however, that is five per cent under $\frac{5}{8}$. If you do so, as soon as there is any wear upon it you are subject to the fine for operating a locomotive with a safety appliance under the size prescribed by law.

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THE PRESIDENT: The next report is that of the Committee on Design, Construction and Inspection of Locomotive Boilers. The committee, I believe, has a verbal report to present.

REPORT OF COMMITTEE ON DESIGN, CONSTRUCTION AND INSPECTION OF LOCOMOTIVE BOILERS.

MR. SELEY: Mr. President and Gentlemen, your Committee on Design, Construction and Inspection of Locomotive Boilers is unable to present a written report on account of the late day of the promulgation by the commission of the boiler-inspection laws.

Last year, due to legislation in Congress, it was thought wise for the Association to put itself on record so far as it could out of convention, in regard to getting out a set of rules covering minimum requirements of boiler inspection. Your committee met and got out such a set of rules, and sent them out in a circular dated September 8, 1910, reading as follows:

CIRCULAR FROM THE COMMITTEE ON DESIGN, CONSTRUCTION AND INSPECTION OF LOCOMOTIVE BOILERS.

To the Members: CHICAGO, ILL., September 8, 1910.

Owing to the request of officers of the American Railway Association for a set of rules containing the essential features of locomotive boiler inspection, for use in connection with government legislation, your Committee on Design, Construction and Inspection of Locomotive Boilers submits, for your approval, the following rules for inspection and care of boilers:

It is to be understood that these rules may be supplemented by such additional regulations as any railway company deems desirable in their own practice to meet local conditions, but it is the thought of the committee that all of the rules submitted are generally applicable and essential, and as such, might be made Recommended Practice of the Association at some future meeting.

It is desired to forward this matter to the American Railway Association as the expression of the American Railway Master Mechanics' Association, on the inspection and care of locomotive boilers, for approval at their October meeting, and you are, therefore, requested to fill out the enclosed informal Letter Ballot before October 1, 1910, mailing it to Mr. J. W. Taylor, Secretary.

You are very respectfully urged to assist the committee in forwarding

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this matter by prompt action, and if these proposed rules can be indorsed by a considerable proportion of the membership, it will greatly aid those concerned in handling legislation.

As this is an informal ballot, it does not affect the Standards or Recommended Practice of the Association, and this matter will be regularly handled in the report of this committee to the next convention.

C. A. SELEY, Chairman,
T. H. CURTIS,
D. R. MACBAIN,
C. E. CHAMBERS,
D. F. CRAWFORD,
F. H. CLARK,
R. E. SMITH,
Committee.

The question is:

Are you in favor of adopting the proposed Rules for Inspection and Care of Locomotive Boilers as Recommended Practice of the Association?

PROPOSED RULES FOR THE INSPECTION AND CARE OF LOCOMOTIVE BOILERS.

I.

RESPONSIBILITY.

The.....will be held responsible for the inspection of the boilers of all locomotives assigned to the division or district.

II.

INSPECTION OF INTERIOR OF BOILER.

(a) TIME OF INSPECTION.— The interior of every boiler shall be thoroughly inspected before the boiler is put into service, and also whenever a sufficient number of flues are removed to allow examination.

(b) METHOD OF INSPECTION.—The entire interior of the boiler must then be examined for cracks, pitting and grooving. The edges of plates, all laps, seams and points where cracks and defects are likely to develop, or which an exterior examination may have indicated, must be given an especially minute examination and reports made of condition found. It must be seen that braces and stays are taut, that pins are properly secured in place, and that each is in condition to support its proportion of the stress.

(c) REPAIRS.— Any boiler developing cracks in the shell which will impair the safety of the boiler shall be taken out of service at once and repaired before it is returned to service.

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(d) LAP JOINT SEAMS.— Every boiler shell having lap joint longitudinal seams without reinforcing plates shall be examined with special care to detect grooving or cracks at the edges of the seams.

III.

INSPECTION OF EXTERIOR OF BOILER.

The jacket and lagging shall be removed to permit inspection of the exterior of the boiler whenever the firebox is renewed or whenever the inspector considers it desirable or necessary in order to thoroughly inspect the boiler.

IV.

TESTING OF BOILERS.

(a) TIME OF TESTING.— Every boiler before being put into service and at least once every twelve months thereafter shall be subjected to hydrostatic pressure twenty-five per cent above the working steam pressure.

Water must be heated immediately before pressure is applied.

(b) REMOVAL OF DOME CAP.— Preceding the hydrostatic test the dome cap must be removed and the interior surface and connections of the boiler examined as thoroughly as the conditions permit.

(c) WITNESS OF TEST.— When the test is being made, authorized representatives familiar with boiler construction must personally witness the test and thoroughly examine the boiler while under test.

(d) REPAIRS AND STEAM TEST.— When all necessary repairs have been completed, the boiler shall be fired up and the steam pressure raised to not less than the allowed working pressure and carefully examined. Any defects discovered must be remedied.

(e) ALLOWED STEAM PRESSURE.—A badge plate showing the allowed steam pressure should be mounted in the cab of each locomotive, preferably located on the boiler head or steam gauge bracket.

(f) REPORTS.—A record of each hydrostatic test must be made on the blank provided for the purpose and each item on the blank to be filled in and the reports signed by the authorized representatives witnessing the test.

V.

STAYBOLT TESTING.

(a) TIME OF TESTING RIGID BOLTS.— The rigid staybolts of all locomotives in service must be tested not less frequently than once each month. The rigid stay bolts must also be tested immediately after each hydrostatic test.

(b) METHOD OF TESTING RIGID BOLTS.— The inspector must tap each

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bolt accessible from the firebox side, and those not thus accessible must be tapped whenever possible on the outside end and judge from the sound or vibration of the sheet which of them are broken.

When stay bolts having telltale holes are used, those visible must, in addition to the hammer test, be carefully inspected to insure that all of the telltale holes are open, using a drill for this purpose when necessary.

(c) METHOD OF TESTING FLEXIBLE STAY BOLTS.— Flexible stay bolts must undergo a special examination not less frequently than once each eighteen months by removing a number of the caps in different locations, for examination of sleeves and bolts, preferably while locomotives are in shop for general repairs, and prior to hydrostatic test.

(d) BROKEN STAY BOLTS.— No boiler must be allowed to remain in service when there are one or more stay bolts broken in the top row of firebox, nor two or more adjacent broken or plugged stay bolts in any part of the firebox, nor three or more broken or plugged stay bolts in a circle four feet in diameter, nor when five or more stay bolts are broken in the entire boiler.

(e) RECORDING OF TEST.— The stay-bolt inspector must keep an accurate record of the location of each imperfect bolt, marking it on the blank provided for that purpose and forward same to.....
.....

VI.

STEAM GAUGES.

(a) TIME OF TESTING.— Steam gauges should be tested not less frequently than once every three months, and also when any irregularity is reported. Gauges found inaccurate must be corrected before being put into service.

(b) Record should be kept of all gauges tested.

VII.

SAFETY VALVES.

(a) SETTING OF VALVES.— Safety valves shall be set by the gauge employed upon the boiler to pop at pressures not exceeding five per cent above the allowed steam pressure, the gauge in all cases to be tested before the safety valves are set or any changes made in the setting.

VIII.

WATER GLASS AND GAUGE COCKS.

(a) TIME OF CLEANING.—All gauge cocks and water glass cocks shall be tested and cleaned of scale and sediment whenever boiler is washed.

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IX.

PLUGS IN FIRE TUBES.

(a) PLUGS PROHIBITED.— No boiler shall remain in service which has one or more fire tubes plugged at both ends of the tube, unless the plugs are securely tied together by means of a rod not less than 5/8 inch diameter.

X.

WASHING BOILERS.

(a) TIME OF WASHING.—All boilers in service shall be thoroughly washed not less frequently than once in thirty days.

(b) WATER TUBES.— Special attention must be given the arch and water bar tubes to see that they are free from scale and sediment.

(c) OFFICE RECORD. A record of all locomotive boiler washouts shall be kept in the office of the railroad company.

These rules were submitted to the membership, as I say. They concluded with a request for an informal ballot to get the mind of the Association, and they were carried practically unanimously, the negative votes being insignificant in number. These rules were brought to the notice of those handling the legislation, and, after the law had been passed, the railroads were invited by the chief boiler inspector to send representatives to a conference at Washington to discuss the matter of the rules, and a Conference Committee of Mechanical Officers appointed as a sub-committee of the Special Committee on the Relations of Railway Operation to Legislation, discussed the matter with the inspectors and the representatives of the employees, arriving at a set of rules with which you are probably familiar through Bulletin No. 17 of the special committee, which has also been copied in some of the railway technical journals. Those rules were revised and finally acted upon at a hearing before the Interstate Commerce Commission on May 29 and were issued, with the ruling of the commission, under date of June 2, 1911, and they have been distributed to the railways.

I doubt if it is necessary to go into any elaborate explanation of this matter. The order is pretty fairly clear. Without having had any legal advice in the matter I will say that as I understand it the railroads that have filed rules have withdrawn them, and all

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the railroads in the country will work under the set of rules which are attached to the order. In our own case we will make these rules supplement the rules of the railroad for a reason which will appear later. The only changes in the rules which are issued with the order, as compared with those which were handed to the commission at the hearing, are in the arrangement of the rules in regard to the numbering of them; they are numbered differently; there are two minor changes in the wording, and one change in the arrangement, the Accident Report Rule being moved from its location in the former set of rules. None of these changes are, I believe, objectionable.

The order of the commission includes copies of the report forms, and it is desired that the railroads print their copies of reports of the identical size and the same arrangement as in the sample in order to have a similarity of reports for convenience of filing.

There is no size given for the quarterly Inspection Report, or Cab Card. A number of us, however, are of the opinion that it is desirable to print it half the size of the other standard report which is 6 by 9, and half of that would be 4½ by 6. Some of our Chicago roads are working toward a standard cardholder, so as to get it a matter of commercial manufacture in large quantities and at cheaper prices.

The report also includes a Specification Card for locomotives, which will keep our mechanical engineers busy figuring out the dimensions and the strengths of present locomotives.

The order concludes with a copy of the law.

Now, taking up the rules: The first eight sections have to do with matters concerning design, figuring out the factor of safety, strength of boiler, responsibility for working pressure, and all that sort of thing. That will have to be taken up by the responsible officers of the railroad and handled in connection with the mechanical engineers' drawing office, and none of these are matters really for the minor officers of the road to consider, except as they are called upon to assist in getting specification-card data.

Rules 9 to 14 are in regard to the inspection of the interior of the boiler. The only remark that I will make on that is to read Rule 12:

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Any boiler developing cracks in the barrel shall be taken out of service at once, thoroughly repaired and reported to be in satisfactory condition before it is returned to service.

As I would interpret that rule: These reports are our own, and we are not required to report repairs to the inspectors.

Inspection of Exterior of Boiler: Rules 15 and 16 are not hard to comply with.

Testing Boilers: Rules 17 to 20. These rules cover the annual test, and there are a great many items in the report which have to be filled in.

Stay-bolt Testing: Rules 21 to 27 explain procedure quite in detail, and we are required to make monthly stay-bolt inspections.

The monthly and the annual forms of report have diagrams on their backs for filling in as to defective stay bolts, but these are only the bolts which are allowed to run; therefore any railroad which desires to have a complete record of its stay bolts will have to maintain its present boiler-inspections forms, provided such forms carry with them diagrams of the broken stay bolts. In our own case we will retain our Rock Island form and do our work just the same as we have heretofore, supplementing it with the Government requirements.

I think it is a little unfortunate that we have not had these rules in our hands long enough so that they could be looked over carefully, so then members would be in a position to ask questions of the members of the committee who are perhaps more familiar with the subject on account of having handled the matter with the inspectors. However, we will be very glad to give any information that may be asked for.

I will file with the stenographer a copy of the order making it a part of this report, and asking that the order be printed complete, together with the forms and the rules.

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BEFORE THE

INTERSTATE COMMERCE COMMISSION.

IN THE MATTER OF THE PREPARATION, APPROVAL AND ESTABLISHMENT OF RULES AND INSTRUCTIONS FOR THE INSPECTION AND TESTING OF LOCOMOTIVE BOILERS AND THEIR APPURTENACES.

June 2, 1911.

ORDER OF THE COMMISSION.

ORDER.

At a General Session of the Interstate Commerce Commission, held at its office in Washington, D. C., on the 2d day of June, A. D. 1911.

Present:

JUDSON C. CLEMENTS,
CHARLES A. PROUTY,
FRANKLIN K. LANE,
EDGAR E. CLARK,
JAMES S. HARLAN,
CHARLES C. MCCHORD,
BALTHASAR H. MEYER,
Commissioners.

IN THE MATTER OF THE PREPARATION, APPROVAL AND ESTABLISHMENT OF RULES AND INSTRUCTIONS FOR THE INSPECTION AND TESTING OF LOCOMOTIVE BOILERS AND THEIR APPURTENANCES.

Whereas the fifth section of the act of Congress, approved February 17, 1911, entitled "An act to promote the safety of employees and travelers upon railroads by compelling common carriers engaged in interstate commerce to equip their locomotives with safe and suitable boilers and appurtenances thereto," provides, among other things, "that each carrier subject to this act shall file its rules and instructions for the inspection of locomotive boilers with the chief inspector within three months after the approval of this act, and after hearing and approval by the Interstate Commerce Commission, such rules and instructions, with such modifications as the commission requires, shall become obligatory upon such carrier: *Provided, however,* That if any carrier subject to this act shall

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fail to file its rules and instructions the chief inspector shall prepare rules and instructions not inconsistent herewith for the inspection of locomotive boilers, to be observed by such carrier; which rules and instructions being approved by the Interstate Commerce Commission, and a copy thereof being served on the president, general manager, or general superintendent of such carrier, shall be obligatory, and a violation thereof punished as hereinafter provided;"; and

Whereas at the expiration of the period of three months after the approval of said act many of the common carriers subject to the provisions thereof had failed to file their rules and instructions for the inspection of locomotive boilers with the chief inspector; and

Whereas the chief inspector thereupon proceeded to prepare for submission to the Interstate Commerce Commission for its approval rules and instructions for the inspection and testing of locomotive boilers and their appurtenances for such carriers so failing to file the same; and

Whereas upon due notice there came on a hearing before the Interstate Commerce Commission in the matter of the approval and establishment of the rules and instructions prepared by the said chief inspector, on the 29th day of May, 1911; and

Whereas such carriers as had filed their rules and instructions for the inspection and testing of locomotive boilers and their appurtenances with the chief inspector within three months after the passage of said act asked, through their representatives at said hearing, that such of said rules and instructions which did not fulfill the requirements of the proposed rules and instructions prepared by the chief inspector be modified to the extent necessary to conform thereto, and that such of said rules and instructions as prescribed a higher standard than that required by the rules and instructions prepared by the chief inspector be regarded as withdrawn from consideration, and joined in a request that such rules and regulations as had been prepared by the chief inspector and approved by the Interstate Commerce Commission be established with uniformity for them and all other carriers subject to the act; and

Whereas at the hearing aforesaid the rules and instructions prepared by the chief inspector were submitted to the Commission for its approval and all parties appearing at said hearing were fully heard in respect to the matters involved, and said proposed rules and instructions having been fully considered by the Commission:

It is ordered, That said rules and instructions for the inspection and testing of locomotive boilers and their appurtenances, as follows, be, and the same are hereby, approved, and from and after the 1st day of July, 1911, shall be observed by each and every common carrier subject to the provisions of the act of Congress aforesaid as the minimum requirements: *Provided,* That nothing herein contained shall be construed as prohibiting any carrier from enforcing additional rules and instructions not inconsistent with the foregoing, tending to a greater degree of precaution against accidents:

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Rules and Instructions for the Inspection and Testing of Locomotive Boilers and Their Appurtenances.

RESPONSIBILITY FOR THE GENERAL CONSTRUCTION AND SAFE WORKING PRESSURE.

1. The railroad company will be held responsible for the general design and construction of the locomotive boilers under its control. The safe working pressure for each locomotive boiler shall be fixed by the chief mechanical officer of the company or by a competent mechanical engineer under his supervision, after full consideration has been given to the general design, workmanship, age and condition of the boiler, and shall be determined from the minimum thickness of the shell plates, the lowest tensile strength of the plates, the efficiency of the longitudinal joint, the inside diameter of the course and the lowest factor of safety allowed.

FACTOR OF SAFETY.

2. The lowest factor of safety to be used for all locomotives in service or under construction on or before January 1, 1912, will be fixed after investigation and hearing and after the expiration of the time allowed for filing specification cards.

3. The lowest factor of safety to be used for all locomotive boilers which are constructed after January 1, 1912, shall be 4.

TENSILE STRENGTH OF MATERIAL.

4. When the tensile strength of steel or wrought-iron shell plates is not known, it shall be taken at 50,000 pounds for steel and 45,000 pounds for wrought iron.

SHEARING STRENGTH OF RIVETS.

5. The maximum shearing strength of rivets per square inch of cross-sectional area shall be taken as follows:

	Pounds.
Iron rivets in single shear	38,000
Iron rivets in double shear	76,000
Steel rivets in single shear	44,000
Steel rivets in double shear	88,000

6. A higher shearing strength may be used for rivets when it can be shown by test that the rivet material used is of such quality as to justify a higher allowable shearing strength.

RULES FOR INSPECTION.

7. The mechanical officer in charge at each point where boiler work is done will be held responsible for the inspection and repair of all locomotive boilers and their appurtenances under his jurisdiction. He must know that all defects disclosed by any inspection are properly repaired before the locomotive is returned to service.

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8. The term inspector as used in these rules and instructions, unless otherwise specified, will be held to mean the railroad company's inspector.

INSPECTION OF INTERIOR OF BOILER.

9. *Time of Inspection.*— The interior of every boiler shall be thoroughly inspected before the boiler is put into service, and whenever a sufficient number of flues are removed to allow examination.

10. *Flues to Be Removed.*— All flues of boilers in service, except as otherwise provided, shall be removed at least once every three years, and a thorough examination shall be made of the entire interior of the boiler. After flues are taken out, the inside of the boiler must have the scale removed and be thoroughly cleaned. This period for the removal of flues may be extended upon application if an investigation shows that conditions warrant it.

11. *Method of Inspection.*— The entire interior of the boiler must then be examined for cracks, pitting, grooving, or indications of overheating and for damage where mud has collected or heavy scale formed. The edges of plates, all laps, seams and points where cracks and defects are likely to develop or which an exterior examination may have indicated, must be given an especially minute examination. It must be seen that braces and stays are taut, that pins are properly secured in place, and that each is in condition to support its proportion of the load.

12. *Repairs.*— Any boiler developing cracks in the barrel shall be taken out of service at once, thoroughly repaired, and reported to be in satisfactory condition before it is returned to service.

13. *Lap-joint Seams.*— Every boiler having lap-joint longitudinal seams without reinforcing plates shall be examined with special care to detect grooving or cracks at the edges of the seams.

14. *Fusible Plugs.*— If boilers are equipped with fusible plugs they shall be removed and cleaned of scale at least once every month. Their removal must be noted on the report of inspection.

INSPECTION OF EXTERIOR OF BOILER.

15. *Time of Inspection.*— The exterior of every boiler shall be thoroughly inspected before the boiler is put into service and whenever the jacket and the lagging are removed.

16. *Lagging to Be Removed.*— The jacket and lagging shall be removed at least once every five years and a thorough inspection made of the entire exterior of the boiler. The jacket and lagging shall also be removed whenever, on account of indications of leaks, the United States inspector or the railroad company's inspector considers it desirable or necessary.

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TESTING BOILERS.

17. *Time of Testing.*— Every boiler, before being put into service and at least once every twelve months thereafter, shall be subjected to hydrostatic pressure twenty-five per cent above the working steam pressure.

18. *Removal of Dome Cap.*— The dome cap and throttle standpipe must be removed at the time of making the hydrostatic test and the interior surface and connections of the boiler examined as thoroughly as conditions will permit. In case the boiler can be entered and thoroughly inspected without removing the throttle standpipe the inspector may make the inspection by removing the dome cap only, but the variation from the rule must be noted in the report of inspection.

19. *Witness of Test.*— When the test is being made by the railroad company's inspector, an authorized representative of the company, thoroughly familiar with boiler construction, must personally witness the test and thoroughly examine the boiler while under hydrostatic pressure.

20. *Repairs and Steam Test.*— When all necessary repairs have been completed, the boiler shall be fired up and the steam pressure raised to not less than the allowed working pressure, and the boiler and appurtenances carefully examined. All cocks, valves, seams, bolts and rivets must be tight under this pressure and all defects disclosed must be repaired.

STAY-BOLT TESTING.

21. *Time of Testing Rigid Bolts.*— All stay bolts shall be tested at least once each month. Stay bolts shall also be tested immediately after every hydrostatic test.

22. *Method of Testing Rigid Bolts.*— The inspector must tap each bolt and determine the broken bolts from the sound or the vibration of the sheet. If stay-bolt tests are made when the boiler is filled with water, there must be not less than fifty pounds pressure on the boiler. Should the boiler not be under pressure, the test may be made after draining all water from the boiler, in which case the vibration of the sheet will indicate any unsoundness. The latter test is preferable.

23. *Method of Testing Flexible Stay Bolts with Caps.*— All flexible stay bolts having caps over the outer ends shall have the caps removed at least once every eighteen months and also whenever the United States inspector or the railroad company's inspector considers the removal desirable in order to thoroughly inspect the stay bolts. The fire-box sheets should be examined carefully at least once a month to detect any bulging or indications of broken stay bolts.

24. *Method of Testing Flexible Stay Bolts without Caps.*— Flexible stay bolts which do not have caps shall be tested once each month the same as rigid bolts, and in addition shall be tested once each eighteen

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months by means of a plug wrench and a bar, sufficient pressure being applied to determine if the bolt is broken.

25. *Broken Stay Bolts.*— No boiler shall be allowed to remain in service when there are two adjacent stay bolts broken or plugged in any part of the fire box or combustion chamber, nor when three or more are broken or plugged in a circle 4 feet in diameter, nor when five or more are broken or plugged in the entire boiler.

26. *Telltale Holes.*— All stay bolts shorter than 8 inches applied after July 1, 1911, except flexible bolts, shall have telltale holes 3/16 inch in diameter and not less than 1¼ inches deep in the outer end. These holes must be kept open at all times.

27. All stay bolts shorter than 8 inches, except flexible bolts and rigid bolts which are behind frames and braces, shall be drilled when the locomotive is in the shop for heavy repairs, and this work must be completed prior to July 1, 1914.

STEAM GAUGES.

28. *Location of Gauges.*— Every boiler shall have at least one steam gauge which will correctly indicate the working pressure. Care must be taken to locate the gauge so that it will be kept reasonably cool, and can be conveniently read by the enginemen.

29. *Siphon.*— Every gauge shall have a siphon of ample capacity to prevent steam entering the gauge. The pipe connection shall enter the boiler direct, and shall be maintained steam-tight between boiler and gauge.

30. *Time of Testing.*— Steam gauges shall be tested at least once every three months and also when any irregularity is reported.

31. *Method of Testing.*— Steam gauges shall be compared with an accurate test gauge or dead-weight tester, and gauges found inaccurate shall be corrected before being put into service.

32. *Badge Plates.*— A metal badge plate showing the allowed steam pressure shall be attached to the boiler head in the cab. If boiler head is lagged, the lagging and jacket shall be cut away so the plate can be seen.

33. *Boiler Number.*— The builder's number of the boiler, if known, shall be stamped on the dome. If the builder's number of the boiler can not be obtained, an assigned number, which shall be used in making out specification card, shall be stamped on dome.

SAFETY VALVES.

34. *Number and Capacity.*— Every boiler shall be equipped with at least two safety valves, the capacity of which shall be sufficient to prevent, under any conditions of service, an accumulation of pressure more than five per cent above the allowed steam pressure.

35. *Setting of Safety Valves.*— Safety valves shall be set by the gauge employed upon the boiler, to pop at pressures not exceeding six pounds

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above the allowed steam pressure, the gauge in all cases to be tested before the safety valves are set or any changes made in the setting. When setting safety valves the water level in the boiler must not be above the highest gauge cock.

36. *Time of Testing.*— Safety valves shall be tested under steam at least once every three months, and also when any irregularity is reported.

WATER GLASS AND GAUGE COCKS.

37. *Number and Location.*— Every boiler shall be equipped with at least one water glass and three gauge cocks. The lowest gauge cock and the lowest reading of the water glass shall be not less than 3 inches above the highest part of the crown sheet. Locomotives which are not now equipped with water glasses shall have them applied on or before July 1, 1912.

38. *Water-glass Valves.*— All water glasses shall be supplied with two valves or shut-off cocks, one at the upper and one at the lower connection to the boiler, and also a drain cock, so constructed and located that they can be easily opened and closed by hand.

39. *Time of Cleaning.*— The spindles of all gauge cocks and water-glass cocks shall be removed and cocks thoroughly cleaned of scale and sediment at least once each month.

40. All water glasses must be blown out and gauge cocks tested before each trip, and gauge cocks must be maintained in such condition that they can be easily opened and closed by hand without the aid of a wrench or other tool.

41. *Water and Lubricator-glass Shields.*— All tubular water glasses and lubricator glasses must be equipped with a safe and suitable shield which will prevent the glass from flying in case of breakage, and such shield shall be properly maintained.

42. *Water-glass Lamps.*— All water glasses must be supplied with a suitable lamp properly located to enable the engineer to easily see the water in the glass.

INJECTORS.

43. Injectors must be kept in good condition, free from scale, and must be tested before each trip. Boiler checks, delivery pipes, feed-water pipes, tank hose and tank valves must be kept in good condition, free from leaks and from foreign substances that would obstruct the flow of water.

FLUE PLUGS.

44. Flue plugs must be provided with a hole through the center not less than ¾ inch in diameter. When one or more tubes are plugged at both ends the plugs must be tied together by means of a rod not less than ⅝ inch in diameter. Flue plugs must be removed and flues prepared at the first point where such repairs can properly be made.

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WASHING BOILERS.

45. *Time of Washing.*— All boilers shall be thoroughly washed as often as the water conditions require, but not less frequently than once each month. All boilers shall be considered as having been in continuous service between washouts, unless the dates of the days that the boiler was out of service are properly certified on washout reports and the report of inspection.

46. *Plugs to Be Removed.*— When boilers are washed, all washout, arch and water-bar plugs must be removed.

47. *Water Tubes.*— Special attention must be given the arch and water-bar tubes to see that they are free from scale and sediment.

48. *Office Records.*— An accurate record of all locomotive boiler washouts shall be kept in the office of the railroad company. The following information must be entered on the day that the boiler is washed:

(a) Number of locomotive.

(b) Date of washout.

(c) Signature of boiler washer or inspector.

(d) Statement that spindles of gauge cocks and water-glass cocks were removed and cocks cleaned.

(e) Signature of the boiler inspector or the employee who removed the spindles and cleaned the cocks.

STEAM LEAKS.

49. *Leaks Under Lagging.*— If a serious leak develops under the lagging, an examination must be made and the leak located. If the leak is found to be due to a crack in the shell or to any other defect which may reduce safety, the boiler must be taken out of service at once, thoroughly repaired and reported to be in satisfactory condition before it is returned to service.

50. *Leaks in Front of Enginemen.*— All steam valves, cocks and joints, studs, bolts and seams shall be kept in such repair that they will not emit steam in front of the enginemen so as to obscure their vision.

FILING REPORTS.

51. *Report of Inspection.*— Not less than once each month, and within ten days after each inspection, a report of inspection, Form No. 1, size 6 by 9 inches, shall be filed with the district inspector of locomotive boilers for each locomotive used by a railroad company, and a copy shall be filed in the office of the chief mechanical officer having charge of the locomotive.

52. A copy of the monthly inspection report, Form No. 1, or a quarterly inspection card, Form No. 2, properly filled out, shall be placed under glass in a conspicuous place in the cab of the locomotive before the boiler inspected is put into service.

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53. Not less than once each year, and within ten days after hydrostatic and other required tests have been completed, a report of such tests showing general condition of the boiler and repairs made shall be submitted on Form No. 3,* size 6 by 9 inches, and filed with the district inspector of locomotive boilers, and a copy shall be filed in the office of the chief mechanical officer having charge of the locomotive. The monthly report will not be required for the month in which this report is filed.

54. *Specification Card.*— A specification card, size 8 by 10½ inches, Form No. 4, containing the results of the calculations made in determining the working pressure and other necessary data, shall be filed in the office of the chief inspector of locomotive boilers, for each locomotive boiler. A copy shall be filed in the office of the chief mechanical officer having charge of the locomotive. Every specification card shall be verified by the oath of the engineer making the calculations, and shall be approved by the chief mechanical officer. These specification cards shall be filed as promptly as thorough examination and accurate calculation will permit. Where accurate drawings of boilers are available, the data for specification card, Form No. 4, may be taken from the drawings, and such specification cards must be completed and forwarded prior to July 1, 1912. Where accurate drawings are not available, the required data must be obtained at the first opportunity when general repairs are made, or when flues are removed. Specification cards must be forwarded within one month after examination has been made, and all examinations must be completed and specification cards filed prior to July 1, 1913, flues being removed if necessary to enable the examination to be made before this date.

ACCIDENT REPORTS.

55. In the case of an accident resulting from failure, from any cause, of a locomotive boiler, or any of its appurtenances, resulting in serious injury or death to one or more persons, the carrier owning or operating such locomotive shall immediately transmit by wire to the chief inspector of locomotive boilers, at his office in Washington, D. C., a report of such accident, stating the nature of the accident, the place at which it occurred, as well as where the locomotive may be inspected, which wire shall be immediately confirmed by mail, giving a full detailed report of such accident, stating, so far as may be known, the causes, and giving a complete list of the killed or injured.

* Form No. 3 should be printed on yellow paper.

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Boiler Form No. 1.

MONTHLY LOCOMOTIVE BOILER INSPECTION AND REPAIR REPORT.

Month of.....191 LOCOMOTIVE { Number..... Initial.....

.....*Company.*

In accordance with the act of Congress approved February 17, 1911, and the rules and instructions issued in pursuance thereof and approved by the Interstate Commerce Commission, I hereby certify that on....., 191 , at....., I inspected the boiler of Locomotive No.....and the appurtenances thereof, operated by the.....Company; that all defects disclosed by said inspection have been repaired, except as noted on the back of this report; that to the best of my knowledge and belief said boiler and appurtenances are in a proper condition for use and safe to operate with a steam pressure of.....pounds per square inch.

1. Safety valves set at.....lbs.....lbs.....lbs., on....., 191
2. Steam gauges tested and left in good condition on ....., 191
3. Was boiler washed and gauge cock and water-glass cock spindles removed and cleaned?.....
4. Were both injectors tested and left in good condition?.....
5. Were all steam leaks repaired?.....
6. Condition of flues and fire-box sheets.....
7. Condition of stay bolts and crown stays.....
8. Number of crown and stay bolts renewed.....
9. Condition of arch or water bar tubes, if used.....
10. Date of previous hydrostatic test.....191...

.....*Inspector.*

STATE OF..... } ss.
COUNTY OF..... }

SUBSCRIBED AND SWORN TO before me this.....day of.....191 , by..... ....., known personally to me to be.....of the..... .....Company at.....

.....*Notary Public.*

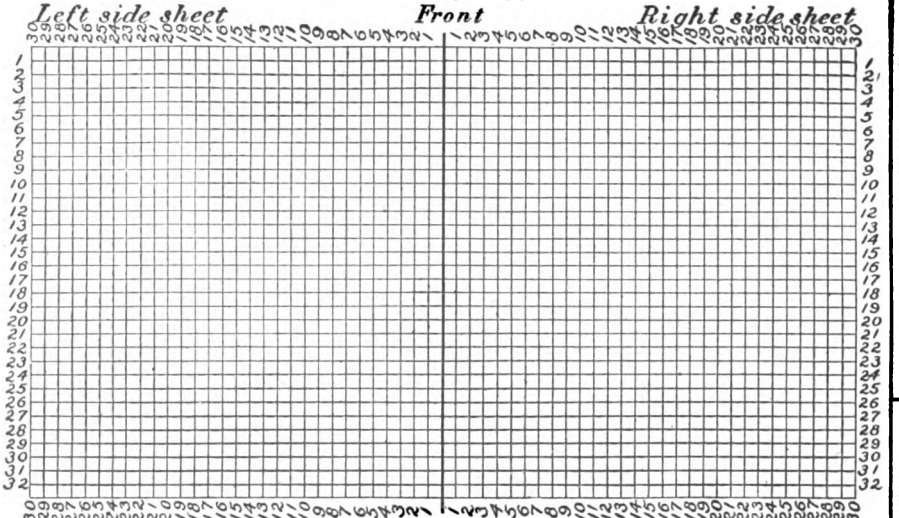
I HEREBY CERTIFY that to the best of my knowledge and belief the above report is correct.
(This certificate not to be folded.)

.....*Officer in Charge.*

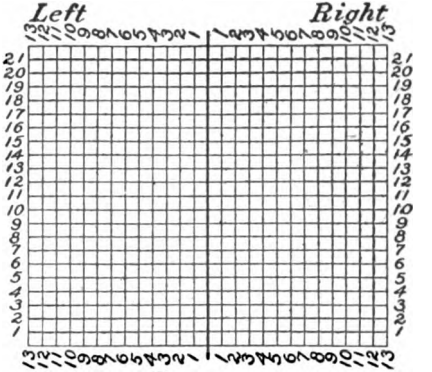
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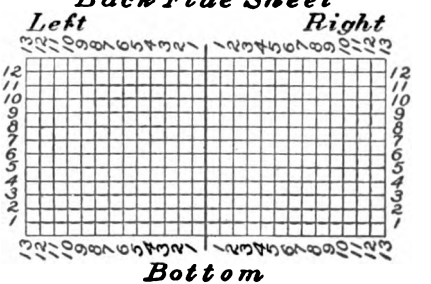
Crown Sheet



Back Sheet



Back Flue Sheet



Location of broken stay and crown bolts which were not renewed must be indicated on diagram.

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Boiler Form No. 2.

QUARTERLY INSPECTION CARD FOR LOCOMOTIVE CAB.

.....
(Name of railroad.)

I hereby certify that the boiler and appurtenances of locomotive No....., operated by the above railroad company, were inspected on....., 191.., as required by law and the rules of the Interstate Commerce Commission.

Safety valves and steam gauges were tested on....., 191..

Last hydrostatic test was made....., 191..

.....

.....

Inspector.

NOTE.— This card must be renewed within three months from date of above inspection.

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Boiler Form No. 3.

ANNUAL LOCOMOTIVE BOILER INSPECTION AND REPAIR REPORT.

M-10

.....*Company.* | LOCOMOTIVE { Number..... Initial.....

In accordance with the act of Congress approved February 17, 1911, and the rules and instructions issued in pursuance thereof and approved by the Interstate Commerce Commission, I hereby certify that on....., 191 , at.....:....., I inspected the boiler of Locomotive No.....and the appurtenances thereof, operated by the.....Company; that all defects disclosed by said inspection have been repaired, except as noted on the back of this report; that to the best of my knowledge and belief said boiler and appurtenances thereof are in a proper condition for use, and safe to operate with a steam pressure of.....pounds per square inch.

1. Date of previous hydrostatic test....., 191
2. Date of previous removal of flues....., 191
3. Date of previous removal of lagging from barrel....., 191
4. Date of previous removal of caps from flexible stay bolts., 191
5. Were all flues removed?.....
6. Number of flues removed.....
7. Was all lagging on fire box removed?.....
8. Was all lagging on barrel removed?.....
9. Were caps removed from all flexible stay bolts?.....
10. Were dome cap and throttle standpipe removed?.....
11. Hydrostatic test pressure of.....pounds was applied.
12. Were both injectors tested and left in good condition?.....
13. Were steam gauges tested and left in good condition?.....
14. Safety valves set to pop at.....pounds.....pounds.....pounds.
15. Was boiler washed; water-glass cocks and gauge cocks cleaned?
16. Were all steam leaks repaired?.....
17. Number of broken crown stays and stay bolts renewed.....
18. Condition of exterior of barrel.....
19. Condition of interior of barrel.....
20. Condition of fire-box sheets and flues.....
21. Condition of arch tubes .....
22. Condition of water-bar tubes .....
23. Condition of cross stays .....
24. Condition of throat stays .....
25. Condition of sling stays .....
26. Condition of crown bars, braces and bolts.....
27. Condition of dome braces .....
28. Condition of back head braces.....
29. Condition of front flue-sheet braces.....

.....*Inspector.*

I HEREBY CERTIFY that to the best of my knowledge and belief the above report is correct.

.....*Officer in Charge.*

STATE OF..... } ss.
COUNTY OF..... }

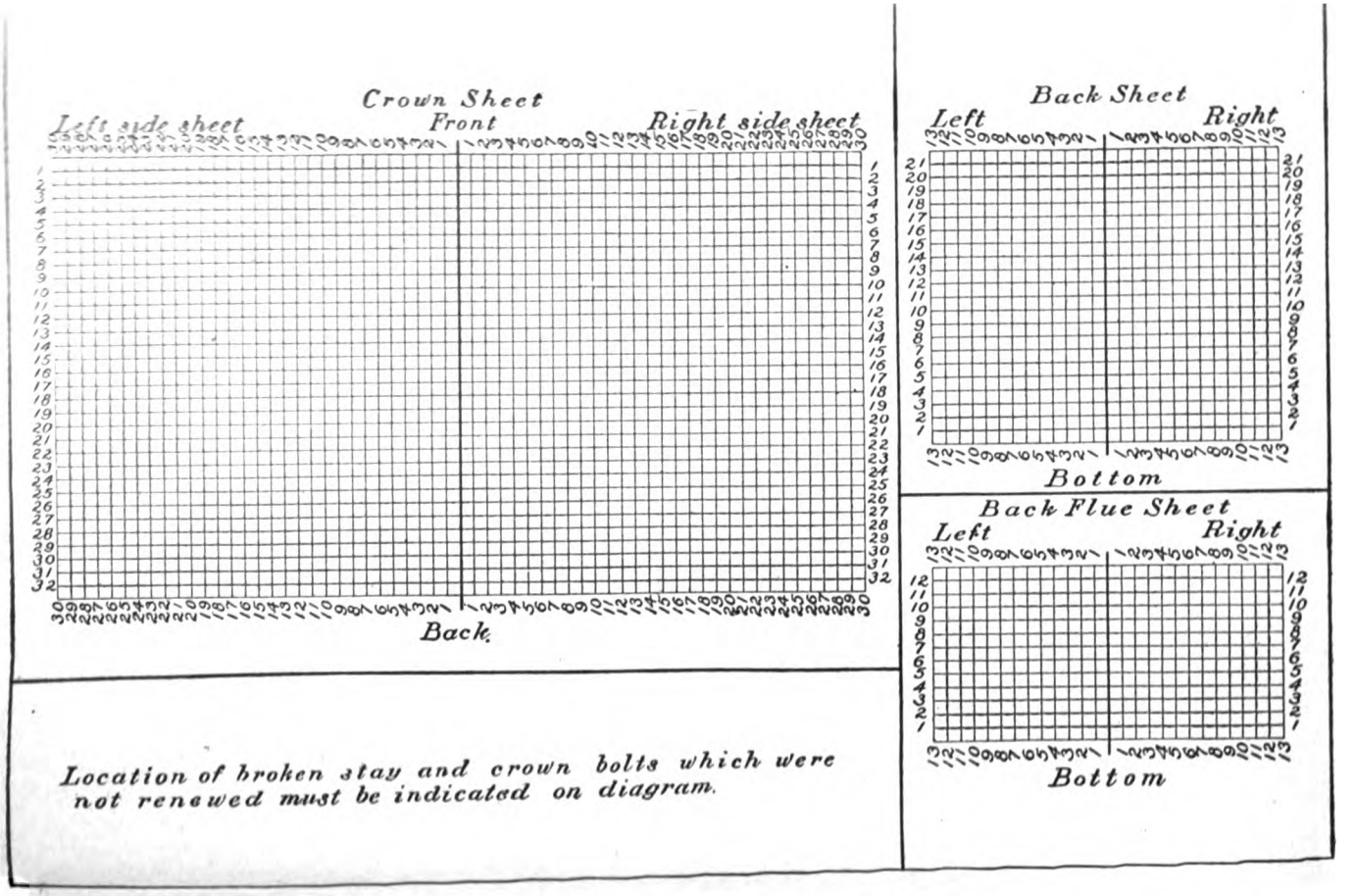
SUBSCRIBED AND SWORN TO before me this.....day of.....191

(This report not to be folded.)

.....*Notary Public.*

12—450

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Location of broken stay and crown bolts which were not renewed must be indicated on diagram.

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Boiler Form No. 4.

SPECIFICATION CARD FOR LOCOMOTIVE No.....

Owned by .....Railroad Company.
Operated by .....Railroad Company.

Builder .....
Builder's No. of boiler.....
When built .....
Where built .....
Type of boiler.....
Material of boiler-shell sheets.....
Material of rivets.....
Dome, where located.....
Grate area in sq. ft.....
Height of lowest reading of gauge glass above crown sheet.....
Height of lowest gauge cock above crown sheet .....
Water-bar tubes, O. diam.....
thickness .....
Arch tubes, O. diam.....
thickness .....
Fire tubes, number.....
Fire tubes, O. diam.....length.....
Safety valves:

No.	Size.	Make.	Style.
.....			
.....			
.....			

Fire-box stay bolts, O. diam.....
spaced .....x.....
Combustion chamber stay bolts, O. diam. .....
Combustion chamber stay bolts, spaced .....x.....
Crown stays, O. diam., top.....
bottom .....
Crown stays, spaced.....x.....
Crown-bar rivets, O. diam., top....
bottom .....
Crown-bar rivets, spaced....x.....
Water space at fire-box ring, sides ..... back..... front.....
Width of water space at sides of fire box, measured at center line of boiler, front.....back.....

Shell sheets:
Front tube.....thick.
1st course ....thick....I. diam.
2d course .....thick....I. diam.
3d course .....thick....I. diam.
Mem.: When courses are not cylindrical, give inside diameter at each end.
Fire box:
Thickness of sheets—
Tube.... Crown.... Side.....
Door .....
Combustion chamber .....
Inside throat (if tube sheet is in two pieces).....
External fire box:
Thickness of sheets—throat....
back head .....
Roof ..... sides .....
Dome, inside diam.....
Thickness of sheet....base....
liner .....
Were you furnished with authentic records of the tests of materials used in boiler?.....
Records on file in the office of the .....of the.....Company show that the lowest tensile strength of the sheets in the shell of this boiler is:
1st course ....pounds per sq. in.
2d course ....pounds per sq. in.
3d course ....pounds per sq. in.
Is boiler shell circular at all points?
.....
If shell is flattened, state location and amount .....
Are all parts thoroughly stayed?...
Are dome and other openings sufficiently reinforced? .....
Is boiler equipped with fusible plugs? .....

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Make working sketch here or attach drawing of longitudinal and circumferential seams used in shell of boiler, indicating on which courses used, and give calculated efficiency of weakest longitudinal seam.

The maximum stresses at the allowed working pressure were found by calculation to be as follows:

Stay bolts at root of thread.....lbs. per sq. in.
Stay bolts at reduced section..... lbs. per sq. in.
Crown stays or crown-bar rivets at root of thread or smallest section, top.....lbs. per sq. in.
Crown stays or crown-bar rivets at root of thread or smallest section, bottom.....lbs. per sq. in.
Round and rectangular braces..... lbs. per sq. in.
Gusset braces.....lbs. per sq. in.
Shearing stress on rivets.....lbs. per sq. in.
Tension on net section of plate in longitudinal seam of lowest efficiency, pounds per sq. in.....

Dimensions and data taken from locomotive were furnished by.....
Data upon which above calculations were made were obtained from drawing No....., dated....., furnished by.....Company.

.....
Mechanical Engineer.

STATE OF .....,.....}
COUNTY OF .....} *ss.*

....., being duly sworn, says that he is the officer who signed the foregoing specification; that he has satisfied himself of the correctness of the drawings and data used; has verified all of the calculations, and has examined the record of present condition of boiler, dated....., and sworn to by inspector....., and believes that the design, construction and condition of boiler No..... renders it safe for a working pressure of.....pounds per square inch.

.....
(Name of Affiant.)

Subscribed and sworn to before me this.....day of....., 19...

.....
Notary Public.

Approved:

.....

And it is further ordered, That a copy of this order be at once served on all common carriers subject to the provisions of said act.

A true copy.

JUDSON C. CLEMENTS,
Chairman.

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[PUBLIC — No. 383.]

[S. 6702.]

AN ACT To promote the safety of employees and travelers upon railroads by compelling common carriers engaged in interstate commerce to equip their locomotives with safe and suitable boilers and appurtenances thereto.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the provisions of this act shall apply to any common carrier or carriers, their officers, agents and employees, engaged in the transportation of passengers or property by railroad in the District of Columbia, or in any Territory of the United States, or from one State or Territory of the United States or the District of Columbia to any other State or Territory of the United States or the District of Columbia, or from any place in the United States to an adjacent foreign country, or from any place in the United States through a foreign country to any other place in the United States. The term "railroad" as used in this act shall include all the roads in use by any common carrier operating a railroad, whether owned or operated under a contract, agreement or lease, and the term "employees" as used in this act shall be held to mean persons actually engaged in or connected with the movement of any train.

SEC. 2. That from and after the first day of July, nineteen hundred and eleven, it shall be unlawful for any common carrier, its officers or agents subject to this act, to use any locomotive engine propelled by steam power in moving interstate or foreign traffic, unless the boiler of said locomotive and appurtenances thereof are in proper condition and safe to operate in the service to which the same is put, that the same may be employed in the active service of such carrier in moving traffic without unnecessary peril to life or limb, and all boilers shall be inspected from time to time in accordance with the provisions of this act, and be able to withstand such test or tests as may be prescribed in the rules and regulations hereinafter provided for.

SEC. 3. That there shall be appointed by the President, by and with the advice and consent of the Senate, a chief inspector and two assistant chief inspectors of locomotive boilers, who shall have general superintendence of the inspectors hereinafter provided for, direct them in the duties hereby imposed upon them, and see that the requirements of this act and the rules, regulations and instructions made or given hereunder are observed by common carriers subject hereto. The said chief inspector and his two assistants shall be selected with reference to their practical knowledge of the construction and repairing of boilers, and to their fitness and ability to systematize and carry into effect the provisions hereof relating to the inspection and maintenance of locomotive boilers. The chief inspector shall receive a salary of four thousand dollars per year and the

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assistant chief inspectors shall each receive a salary of three thousand dollars per year; and each of the three shall be paid his traveling expenses incurred in the performance of his duties. The office of the chief inspector shall be in Washington, District of Columbia, and the Interstate Commerce Commission shall provide such stenographic and clerical help as the business of the offices of the chief inspector and his said assistants may require.

SEC. 4. That immediately after his appointment and qualification the chief inspector shall divide the territory comprising the several States, the Territories of New Mexico and Arizona and the District of Columbia into fifty locomotive-boiler inspection districts, so arranged that the service of the inspector appointed for each district shall be most effective, and so that the work required of each inspector shall be substantially the same. Thereupon there shall be appointed by the Interstate Commerce Commission fifty inspectors of locomotive boilers. Said inspectors shall be in the classified service and shall be appointed after competitive examination according to the law and the rules of the Civil Service Commission governing the classified service. The chief inspector shall assign one inspector so appointed to each of the districts hereinbefore named. Each inspector shall receive a salary of one thousand eight hundred dollars per year and his traveling expenses while engaged in the performance of his duty. He shall receive in addition thereto an annual allowance for office rent, stationery and clerical assistance, to be fixed by the Interstate Commerce Commission, but not to exceed in the case of any district inspector six hundred dollars per year. In order to obtain the most competent inspectors possible, it shall be the duty of the chief inspector to prepare a list of questions to be propounded to applicants with respect to construction, repair, operation, testing and inspection of locomotive boilers, and their practical experience in such work, which list, being approved by the Interstate Commerce Commission, shall be used by the Civil Service Commission as a part of its examination. No person interested, either directly or indirectly, in any patented article required to be used on any locomotive under supervision or who is intemperate in his habits shall be eligible to hold the office of either chief inspector or assistant or district inspector.

SEC. 5. That each carrier subject to this act shall file its rules and instructions for the inspection of locomotive boilers with the chief inspector within three months after the approval of this act, and after hearing and approval by the Interstate Commerce Commission, such rules and instructions, with such modifications as the Commission requires, shall become obligatory upon such carrier: *Provided, however,* That if any carrier subject to this act shall fail to file its rules and instructions, the chief inspector shall prepare rules and instructions not inconsistent herewith for the inspection of locomotive boilers, to be observed by such carrier; which rules and instructions, being approved by the Interstate Commerce Commission, and a copy thereof being served upon the president, general

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manager, or general superintendent of such carrier, shall be obligatory, and a violation thereof punished as hereinafter provided: *Provided also,* That such common carrier may from time to time change the rules and regulations herein provided for, but such change shall not take effect and the new rules and regulations be in force until the same shall have been filed with and approved by the Interstate Commerce Commission. The chief inspector shall also make all needful rules, regulations and instructions not inconsistent herewith for the conduct of his office and for the government of the district inspectors: *Provided, however,* That all such rules and instructions shall be approved by the Interstate Commerce Commission before they take effect.

SEC. 6. That it shall be the duty of each inspector to become familiar, so far as practicable, with the condition of each locomotive boiler ordinarily housed or repaired in his district, and if any locomotive is ordinarily housed or repaired in two or more districts, then the chief inspector or an assistant shall make such division between inspectors as will avoid the necessity for duplication of work. Each inspector shall make such personal inspection of the locomotive boilers under his care from time to time as may be necessary to fully carry out the provisions of this act, and as may be consistent with his other duties, but he shall not be required to make such inspections at stated times or at regular intervals. His first duty shall be to see that the carriers make inspections in accordance with the rules and regulations established or approved by the Interstate Commerce Commission, and that carriers repair the defects which such inspections disclose before the boiler or boilers or appurtenances pertaining thereto are again put in service. To this end each carrier subject to this act shall file with the inspector in charge, under the oath of the proper officer or employee, a duplicate of the report of each inspection required by such rules and regulations, and shall also file with such inspector, under the oath of the proper officer or employee, a report showing the repair of the defects disclosed by the inspection. The rules and regulations hereinbefore provided for shall prescribe the time at which such reports shall be made. Whenever any district inspector shall, in the performance of his duty, find any locomotive boiler or apparatus pertaining thereto not conforming to the requirements of the law or the rules and regulations established and approved as hereinbefore stated, he shall notify the carrier in writing that the locomotive is not in serviceable condition, and thereafter such boiler shall not be used until in serviceable condition: *Provided,* That a carrier, when notified by an inspector in writing that a locomotive boiler is not in serviceable condition, because of defects set out and described in said notice, may within five days after receiving said notice appeal to the chief inspector by telegraph or by letter to have said boiler reëxamined, and upon receipt of the appeal from the inspector's decision, the chief inspector shall assign one of the assistant chief inspectors or any district inspector other than the one from whose decision the appeal is taken to reëxamine and inspect

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said boiler within fifteen days from date of notice. If upon such reëxamination the boiler is found in serviceable condition, the chief inspector shall immediately notify the carrier in writing, whereupon such boiler may be put into service without further delay; but if the reëxamination of said boiler sustains the decision of the district inspector, the chief inspector shall at once notify the carrier owning or operating such locomotive that the appeal from the decision of the inspector is dismissed, and upon the receipt of such notice the carrier may, within thirty days, appeal to the Interstate Commerce Commission, and upon such appeal, and after hearing, said Commission shall have power to revise, modify or set aside such action of the chief inspector and declare that said locomotive is in serviceable condition and authorize the same to be operated: *Provided further,* That pending either appeal the requirements of the inspector shall be effective.

SEC. 7. That the chief inspector shall make an annual report to the Interstate Commerce Commission of the work done during the year, and shall make such recommendations for the betterment of the service as he may desire.

SEC. 8. That in the case of accident resulting from failure from any cause of a locomotive boiler or its appurtenances, resulting in serious injury or death to one or more persons, a statement forthwith must be made in writing of the fact of such accident, by the carrier owning or operating said locomotive, to the chief inspector. Whereupon the facts concerning such accident shall be investigated by the chief inspector or one of his assistants, or such inspector as the chief inspector may designate for that purpose. And where the locomotive is disabled to the extent that it can not be run by its own steam, the part or parts affected by the said accident shall be preserved by said carrier intact, so far as possible, without hindrance or interference to traffic, until after said inspection. The chief inspector or an assistant or the designated inspector making the investigation shall examine or cause to be examined thoroughly the boiler or part affected, making full and detailed report of the cause of the accident to the chief inspector.

The Interstate Commerce Commission may at any time call upon the chief inspector for a report of any accident embraced in this section, and upon receipt of said report, if it deems it to the public interest, make reports of such investigations, stating the cause of accident, together with such recommendations as it deems proper. Such reports shall be made public in such manner as the Commission deems proper. Neither said report nor any report of said investigation nor any part thereof shall be admitted as evidence or used for any purpose in any suit or action for damages growing out of any matter mentioned in said report or investigation.

SEC. 9. That any common carrier violating this act or any rule or regulation made under its provisions or any lawful order of any inspector shall be liable to a penalty of one hundred dollars for each and every

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such violation, to be recovered in a suit or suits to be brought by the United States attorney in the district court of the United States having jurisdiction in the locality where such violation shall have been committed; and it shall be the duty of such attorneys, subject to the direction of the Attorney-General, to bring such suits upon duly verified information being lodged with them, respectively, of such violations having occurred; and it shall be the duty of the chief inspector of locomotive boilers to give information to the proper United States attorney of all violations of this act coming to his knowledge.

SEC. 10. That the total amounts directly appropriated to carry out the provisions of this act shall not exceed for any one fiscal year the sum of three hundred thousand dollars.

Approved, February 17, 1911.

THE PRESIDENT: Gentlemen, you have heard the very interesting report of the committee, and, unless there is objection, it will be received and opened for discussion. If there is anything not clearly understood about this report this is the time to raise a question and obtain information.

MR. C. B. YOUNG (C. B. & Q. Ry.): In connection with the cab card, Mr. Seley has suggested that it be one-half the size of the monthly and annual statements. I had thought that if we made that the size of a library card, 3 by 5 inches, it would be a convenient size for the locomotive cab, reduce the amount of stationery, and still have room for all the information required and the blanks could be filled in easily. I think the suggestion to get up a standard form of holder is a good one, too. I think that ought to be embodied as a recommendation to the Association. I would suggest that the holder when designed be made as near dustproof and dampproof as possible, because the steam and the dirt in the cab of a locomotive quickly soils the sheet so that you can not read it unless it is pretty tight at the joints. One other point, in connection with the monthly form: As I understand it the Government requirement gives an option between the card form and the larger sized blank. I believe we should have a practice recommended as to which of those the railroads will place in the cab, because if the order could be made uniform it would be very desirable, I think.

THE PRESIDENT: Are there any further remarks upon this report.

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MR. BENTLEY: It seems to us that one of the hardest jobs is when these monthly and annual reports have to be sworn to. That means, of course, that you must have a notary public in every roundhouse where repairs and inspections are made. I understand that in the State of New York the inspector simply takes oath that all the statements he puts on the card will be the truth. If it is possible to do that in the roundhouses, let the inspectors certify under oath to the correctness of the statements that he puts on the cards; it would simplify the work very considerably. I would ask if there is anybody here who has had experience under the operation of that law in New York or in the State of Pennsylvania?

MR. MACBAIN: With the permission of the convention I would like to have Mr. D. P. Robinson, Assistant Federal Boiler Inspector, say something to us on this subject.

MR. CRAWFORD: I move that the courtesy of the floor be extended to Mr. Robinson. Seconded.

THE PRESIDENT: All in favor of the motion say aye; opposed, no. Carried.

Mr. Robinson, we should be glad to hear from you.

D. P. ROBINSON: Mr. President, I did not quite catch the inquiry that was made.

THE PRESIDENT: Mr. Bentley asks whether or not it would be possible for the inspector who makes the inspection in the roundhouses to himself make oath to the correctness of the statements that he puts upon the card, instead of having that done by the roundhouse men.

MR. BENTLEY: I have just had a talk with Mr. Robinson and I find I have been misinformed. I may have had a dream about it, but was under the impression that some one told me that was how it was handled, and it seemed a much simpler way than having a notary public in each roundhouse.

MR. ENRIGHT: In connection with what Mr. Bentley is saying, it is my understanding that the quarterly card is the one to be posted in the engine cab; it is not a sworn statement, simply a quarterly report, containing the signatures of the party who took care of the gauge cocks and water glasses and the inspector who

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looked after the boiler, so there should be no delay to power waiting for a sworn statement to be posted in the cab if this quarterly card is used.

MR. F. C. CLEAVER (Rutland R. R.): I would ask if it is necessary to have a second card pocket in the cab for the Federal card? Does the Federal law specifically state that this card must be exposed? It has been suggested that we could carry two cards in one pocket. I would like some information on that subject.

THE PRESIDENT: I do not understand your question, Mr. Cleaver. There is not anything in the law which says you must put in two cards.

MR. CLEAVER: In New York State we have to carry a card. Now, can we have the Federal card in the pocket we already have — the pocket which has been provided for the New York State card?

THE PRESIDENT: The law specifically states what we must do; there must be a card pocket and a glass over the card. As I understand it we can put four cards in four separate pockets or we can put the four cards in one pocket. I believe this Association should either have the State laws repealed or modified to conform to the Government law, so that it will not be necessary to inspect the boilers to conform with the laws of the State of New York or any other State, and then inspect the boilers in conformance with the Federal requirements.

MR. CLEAVER: That might take four or five years. I am asking whether we can use our present pocket in complying with our New York State laws.

THE PRESIDENT: If the cards are not covered I do not see why you can not use the same pocket.

MR. MACBAIN: It is our intention in New York and Pennsylvania to put both cards in the same holder. We have it arranged now so that all these cards referring to the States of New York, Ohio and Pennsylvania shall go into one holder, and we intend to put them and the Federal card in the same holder.

THE PRESIDENT: It seems to me that answers your question, Mr. Cleaver.

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MR. MANNING: How is Mr. MacBain going to keep the cards exposed, if he puts them all in one pocket? The law of the State of New York and the Federal law requires them to be under glass, exposed.

MR. MACBAIN: The inspector can pull the cards out and inspect them.

MR. MANNING: Will that comply with the law?

MR. MACBAIN: I think so.

MR. MANNING: I would like to hear from Mr. Robinson on that matter. My understanding is that the New York State law called for one pocket and the Federal law called for another, and both cards should be exposed so you can stand on the deck and read them. If I am wrong I want to find it out.

MR. CLEAVER: I looked that up carefully, and I think the Federal law does not state that the card shall be read through the glass; it simply states that the card shall be under glass. Apparently, you can turn it wrong-side out, as far as I understand the Federal law.

MR. MILLER: That I may be clear on some of these matters, I would like to ask Mr. Seley if the stay-bolt chart shown on the back of the Federal report is to be filled out in case the broken stay bolts are replaced before the chart is made out for the Government. It will make quite a difference whether we show these broken stay bolts on this chart, or whether they are eliminated from the chart, except in cases where they are allowed to run in a broken condition.

MR. WELLS: I have had considerable anxiety about the same point that Mr. Miller speaks of, that is the monthly report, and I was under the impression at first that the report had to be filed in the cab every month, but I am very happy to learn that it is only the quarterly report that has to be filed in the cab — the monthly report is simply made out and forwarded to the Commission. That simplifies the matter a great deal, because as we work in Ohio we have discovered that it entails a good deal of trouble to get a new inspection at the end of each three months, and get it certified to by a notary public and keep the engines going as they should. When I thought that was liable to happen

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every thirty days, I was very much concerned about it, as it would put us to considerable trouble, but it is only the quarterly card that goes in the cab — the monthly card or report is forwarded to the Commission.

MR. ENRIGHT: Would it not be well for Mr. Seley to give a definition of flue plug for the benefit of those present who are operating engines in bad-water districts? I understand a definition was obtained from the chief inspector and others at a meeting the subcommittee had with them May 27 last.

MR. HAIG: I may have misunderstood something in the circular first sent out by Mr. Seley and wish to ask for enlightenment. Article 8, of the circular, states that all gauge cocks and water-glass cocks shall be tested and cleaned of scale and sediment whenever boiler is washed. In some districts it is necessary to wash boilers every round trip, yet I do not think it should be necessary to clean out the cocks so frequently. I should appreciate some information on this before the subject is closed.

MR. WELLS: I will say for the benefit of the gentleman, all that means is to know that they are open, which you want to know anyhow. It does not mean they shall be cleaned if they do not need cleaning. It means that you shall know that they are open and free.

MR. SMITH: We do not anticipate any trouble in carrying out this law, which is practically the same as the New York State law under which we are operating, and I understand we will be obliged to have the certificates in the cab under glass, the same as we now carry the certificate of the New York State inspection.

It seems to me, and I hope that some action will be taken to the end that the Federal laws supersede the State laws.

Our roundhouse clerks are notaries public, and the inspectors go before them and make out their inspection reports, which are sworn to and forwarded in the regular way. This is not done at one time, but it is a continuous performance, and goes on at night as well as in the daytime. In engine houses where we have a large number of engines the night clerks are notaries as well as the day clerks.

The copy of the law did not reach my desk until just as I was

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leaving the office, and I do not know the time given to fill out the specification cards for boilers. Of course, those of us who have had engines running in the State of New York can get copies of those specification cards, which will make very much less work, but I do not know how much time we have in which to file these cards.

MR. CRAWFORD: We have been working under the laws of the State of Ohio and the State of Pennsylvania, and our lines East have been working under the laws of the State of New York. We are, therefore, somewhat familiar with this system of inspection and reporting. It has really made no change in our system of inspection at all, but it made a change in the system of reporting to the extent of reporting to the various commissions. I think we should do everything possible and in good faith in coöperating and assisting the Federal inspectors and the State inspectors as far as we can. I should say for the present put all the cards necessary in the cab, exposing them; they are put there to assist the inspector; let him go on and see that the engine has been inspected within the proper time.

I feel all here can do a great deal with the gentlemen on the various State commissions to get them to adopt and use, or permit the use of, a Federal quarterly inspection card as covering the whole situation, the reports to be sent to the Commission as may be decided by our various legal departments. We have had a little experience along that line, in that the form promulgated by the Pennsylvania Commission differed slightly from the form put out by the Ohio Commission, and the Pennsylvania and Ohio reports also differed slightly from that of the New York Commission. Representatives of the three commissions have met at some place and have agreed that the one form that we use shall be used by the three commissions. The form in question reads: "This boiler has been inspected in accordance with the requirements of the States of New York, Pennsylvania and Ohio." That one form answers the purpose. I believe we could present this matter to the various State commissions in such a form that would assist us in simplifying the work as much as possible, and I think it is distinctly up to us to coöperate with both the State and Federal commissions to carry out this work.

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THE PRESIDENT: If there is nothing further, I will ask Mr. Seley to close the report of the committee by answering such questions as have been asked.

MR. SELEY: As regards the size of the cab card, would say there has been nothing done definitely in this matter by us in Chicago except to consider a size one-half the size of the monthly and annual reports, which would give us a card 4½ by 6. I am advised that 4½ by 6 is not a standard paper size, 3½ by 5½ is postal size and 3 by 5 is library size. Inasmuch as the amount of printing to be done on the card would readily be shown on one of these smaller sizes, further consideration may lead us to adopt one or the other of them.

As regards the design of the card holder, would say that we have considered a pressed steel affair, that is fastened up in the cab, has guides on each side and stops at the bottom and is open at the top. Into that is dropped another case, which holds the card, also of pressed steel with glass front and a couple of clips at the back, to press the card tightly against the glass, and keep the dirt and moisture out of it.

That being dropped down into the holder makes a very neat arrangement, and if you should run in territory where you might be afraid of malicious interference and trouble with the maintenance of the card it is an easy matter to secure a piece of moulding over the tops of the case, so that the card could not be removed without the removal of the moulding. That is a matter of detail which almost anybody can take care of.

As regards the oath by the officers, I doubt very much if we can get away from the notarial requirements, as the law requires these reports to be under oath, and that is really a matter for our legal departments rather than us to handle.

I would strongly urge the use of the quarterly card for the cab card. It is true the rules will permit the filing of a monthly inspection report as a permissive card for operating the locomotive, but that involves a case 6 by 9. I think you will agree with me that is too large a case to put in a cab.

Regarding the stay-bolt chart would say for Mr. Miller's information that the reports state very plainly that the location of broken stay and crown bolts which were not renewed must be

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indicated on the diagram, so that any bolts which are renewed are not shown on the diagram. The report is to indicate the condition of the engine when it goes into service after inspection, but not what its condition was before that inspection. The condition of your stay bolts will have to be mapped out on your own forms, if you wish a complete history regarding them.

Regarding the fire-plug matter. Would say that I wrote to the chief inspector for an interpretation and I received the following reply: "Inasmuch as the rules do not prohibit the use of thimbles, I think it is a matter in which the railroads must use their own discretion in regard to their use. However, I think the indiscriminate use of thimbles should be discouraged, and they should only be used when the beading is in good condition and the thimbles are properly applied." As I understand the matter, the flue plug, as stated in the rule, is a plug having a hole through the center not less than ¾ of an inch; solid plugs are not allowed. If that hole is larger than ¾ of an inch, reasonably larger, say 1 inch or 1¼ inches, it would be construed as a thimble, but they wish to discourage the use of them to the greatest possible extent, and I think that is desirable.

The cleaning of water glasses and gauge cocks is a little mixed. Rule 39 reads as follows: "The spindles of all gauge cocks and water glass cocks shall be removed and cocks thoroughly cleaned of scale and sediment at least once each month." Now, if you will turn to Rule 48, which is the office record, it reads as follows: "An accurate record of all locomotive boiler washouts shall be kept in the office of the railroad company. The following information must be entered on the day the boiler is washed: (a) Number of locomotive; (b) Date of washout; (c) Signature of boiler washer or inspector; (d) Statement that spindle gauge cocks and water glass cocks were removed and cocks cleaned; (e) Signature of the boiler inspector or the employee who removed the spindles and cleaned the cocks."

Inasmuch as much weight is given to getting these statements and signatures, I should be inclined to construe that every time you wash a boiler out you ought to do the other, although it says in Rule 39, "once a month," which might be answered in this way — in many sections of the country where the water condi-

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tions are so very good, you would not wash out more than once a month. To fulfil the requirements, the rule would secure the cleaning of these cocks at that same time.

As regards the filing of specification cards I will say that we have a two-year period in which to file cards, although if we have definite information in the office available, the rule says file them at once or as soon as you can prepare them, but where there is little information and the specification card has to be made up from an actual inspection of the boilers, and to cover a large number of old engines, we have a time of two years from July 1.

All boilers built after January 1 next must have a factor of safety of at least 4. That time was given so as to enable pending contracts to be filled and deliveries of locomotives to be made, and will give us ample time to check over and change our standard specifications and drawings so that for our new equipment after January 1 next we will have a factor of not less than 4.

The President suggests that we take up a little more time in regard to this washing-out matter. On the monthly locomotive boiler inspection and repair report, question 3 reads: "Was boiler washed and gauge cock and water glass cock spindles removed and cocks cleaned?" That, of course, will be answered, "yes," or you would be violating the requirement to do it in every thirty days.

Now, as regards your office record, it should be accessible to the Government inspector, and, for the information of your own office force, the right way to do it is to clean these things and have the signatures for every washing, and then in case anything happens you have a clear record. You do not have to swear to that, you do not have to get any signatures other than for the purposes of your own office records.

MR. CRAWFORD: Inasmuch as the Federal Inspection Rules become effective July 1, and we will, therefore, not have time to refer the question of the size of this card to the Committee on Standards, I would move that the Association adopt as recommended practice, at least, the size 3 by 5 inches, the library-card size, which will enable a copy to be kept, if so desired, in your regular card catalogue file. (The motion was put and carried.)

MR. BENTLEY: It seems to me a vote of thanks is in order to

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Mr. Seley and the committee who had the Federal Boiler Bill in hand. They have done a tremendous amount of work. They have made trips to Washington and interviewed the chief inspector and his assistants, they have done very painstaking and careful work in connection with this bill, and they have also given valuable information to us individually and to the organization collectively, and I move a vote of thanks be returned to Mr. Seley and the other members of the Federal Boiler Bill Committee.

The motion was seconded and carried unanimously.

MR. SELEY: In order that you may know to whom you have voted the thanks of the Association, I would say that my associates were the Presidents of the two Associations, also Mr. Crawford and Mr. MacBain, all of whom should share most liberally in any credit given to the committee.

THE PRESIDENT: The next report is that of the Committee on Contour of Tires, Mr. W. C. A. Henry, Chairman.

Mr. Henry presented the report as follows:

REPORT OF COMMITTEE ON CONTOUR OF TIRES.

To the Members:

Your Committee on the Contour of Tires has been instructed to give consideration to the following and make recommendations: The desirability of adopting the M. C. B. standard contour for engine-truck wheels, tender-truck wheels, driving and trailing wheels, also limit of wear of tread, shop and road limit of last turning, maximum height of flange, thickness of flange and gauges.

As the present standard contour for cast-iron wheels of the American Railway Master Mechanics' Association is identical with the 1909 standard of the Master Car Builders' Association, we are assuming that our instructions as to contour refer to steel and steel-tired wheels only.

Replies to our circular of inquiry indicate that the M. C. B. 1909 contour is being very generally used for engine-truck and tender-truck wheels. Some roads have already adopted this contour for flanged driving-wheel tires as well. We feel that this contour is desirable for all flanged wheels under locomotives and tenders for the same reason that it is desirable for car wheels, in addition to which is the feature of uniformity.

The present A. R. M. M. A. standards call for six widths of flanged tires, and five widths of plain tires, as follows:

Flanged tires	5 in.	5¼ in.	5½ in.	5¾ in.	6 in.	6¼ in.
Plain tires	6 in.	6¼ in.	6½ in.	6¾ in.	7 in.	

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Replies from the manufacturers of steel tires indicate that of the flanged tires manufactured by them, there are practically but two widths, namely, 5½ inches and 5¾ inches, the large majority being the former. In the case of plain tires the prevailing widths manufactured are 6 inches, 6½ inches and 7½ inches, there being little demand for the 6¼-inch and 6¾-inch widths. It is the opinion of your committee that one standard for cast-iron and one for steel and steel-tired flanged wheels, namely, the M. C. B. 1909 standards, and three widths of the present A. R. M. M. A. contour for plain tires will meet all requirements and be to the advantage

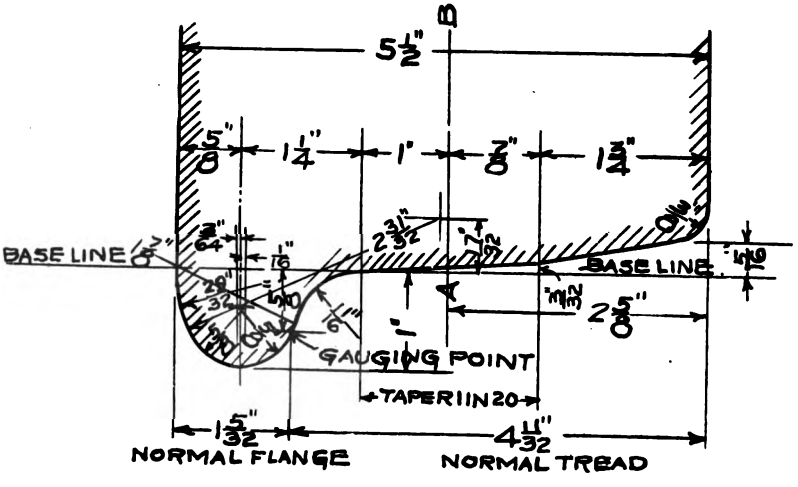


FIG. 1

of all concerned, due to the fewer number of standards. Fig. 1 shows the contour which we recommend for steel and steel-tired wheels.

The prevailing limit of wear of tread or channeling for all wheels under locomotives and tenders is ¼ inch for locomotives in road service and 5/16 inch for locomotives in shifting service, which we feel is good practice.

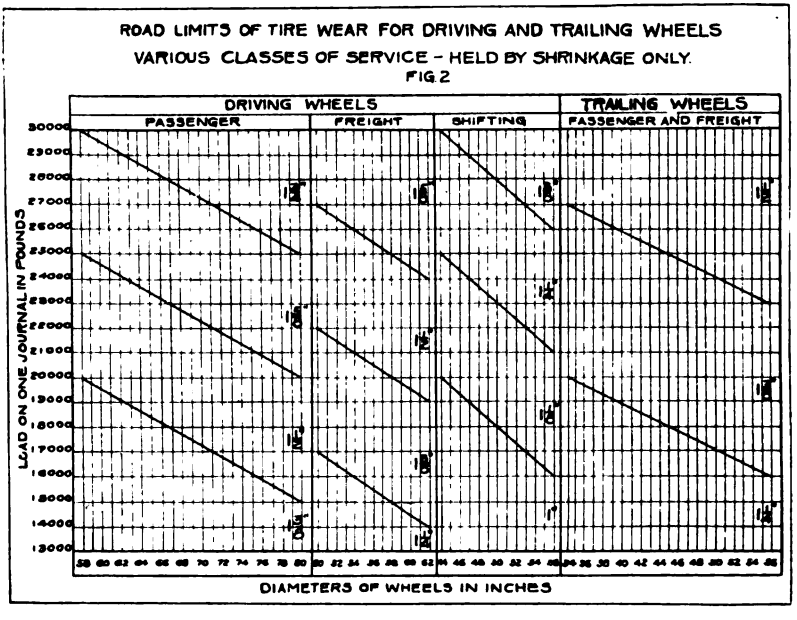
In investigating the subject of limits of wear of driving-wheel tires we have found the greatest variation. After full consideration, it does not seem possible, or advisable, to establish a minimum road limit to be followed by all roads. Where long, steep grades necessitate heavy braking, or severe weather conditions result in frozen roadbed for long periods of time, tires can not be worn to the same degree of thinness as where these conditions do not prevail. Also, the use of retaining rings, which practice, however, is not universal, has a bearing on tire thickness. After consideration of all the data available, we feel that the limits prescribed on the chart

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submitted as a portion of our recommendations will be suitable for roads not having severe grades, or extremely cold weather, and not using retaining rings. Where these conditions prevail, or retaining devices are used, such deviations will have to be made as experience indicates are desirable.

The prevailing practice is to establish the shop limit of thickness of tires ¼ inch above the road limit. This limit is strictly one of economy and not safety, and will vary with the facilities for doing the work. We, therefore, hesitate to recommend a definite shop limit.

The M. C. B. limit for thickness of tire or rim for steel and steel-tired wheels is being generally followed in the case of engine truck and tender



truck wheels with satisfactory results, and your committee recommends the same limits be adopted. See Figs. 3, 4, 5 and 6.

The M. C. B. Association has already adopted a maximum height for flanges, of 1½ inches. This was considered the maximum height flange that would not, in service, damage track bolts, filler blocks, etc. There is no reason why this maximum height should be deviated from.

The question of gauges is one in which there is practically no uniformity, each road apparently having gotten up a gauge to suit its individual views. We are submitting recommendations for a shop or roundhouse gauge on which can be read direct the important dimensions; namely, channeling of tire, height of flange, and thickness of tire.

It has been suggested that the number of brackets on standard wheel

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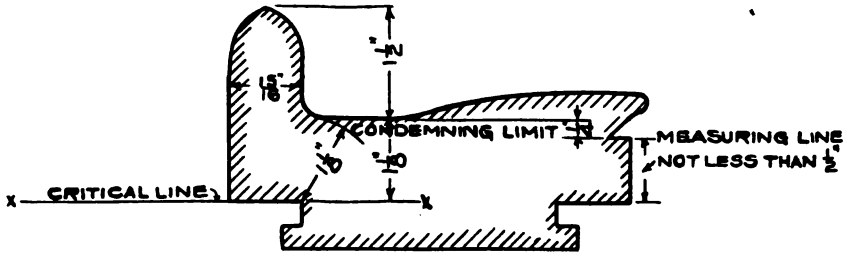


FIG. 3

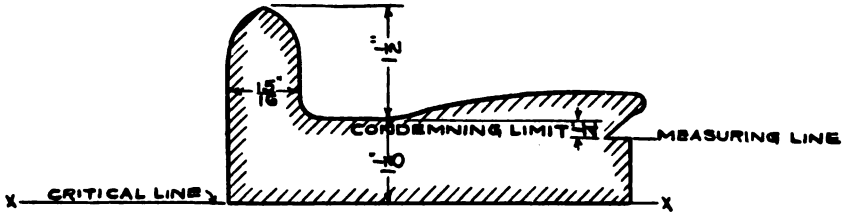


FIG. 4

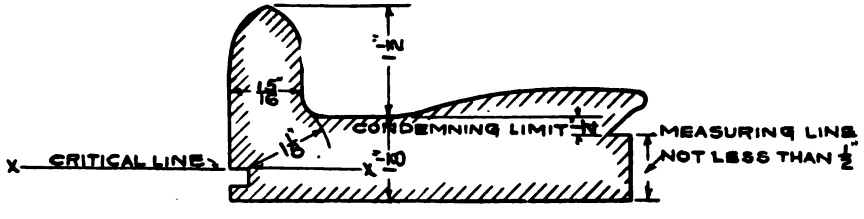


FIG. 5

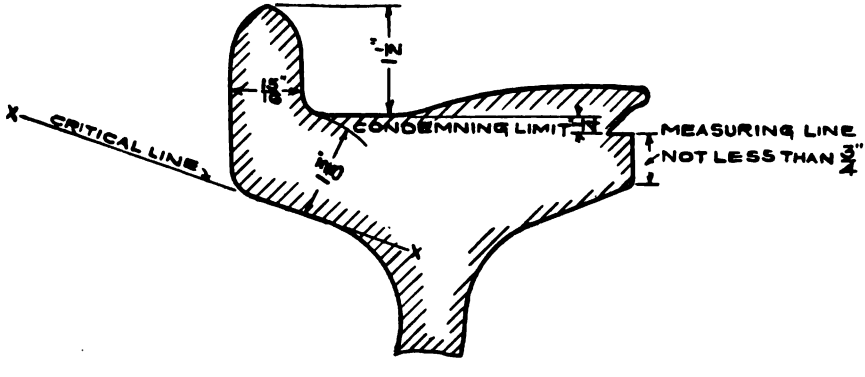
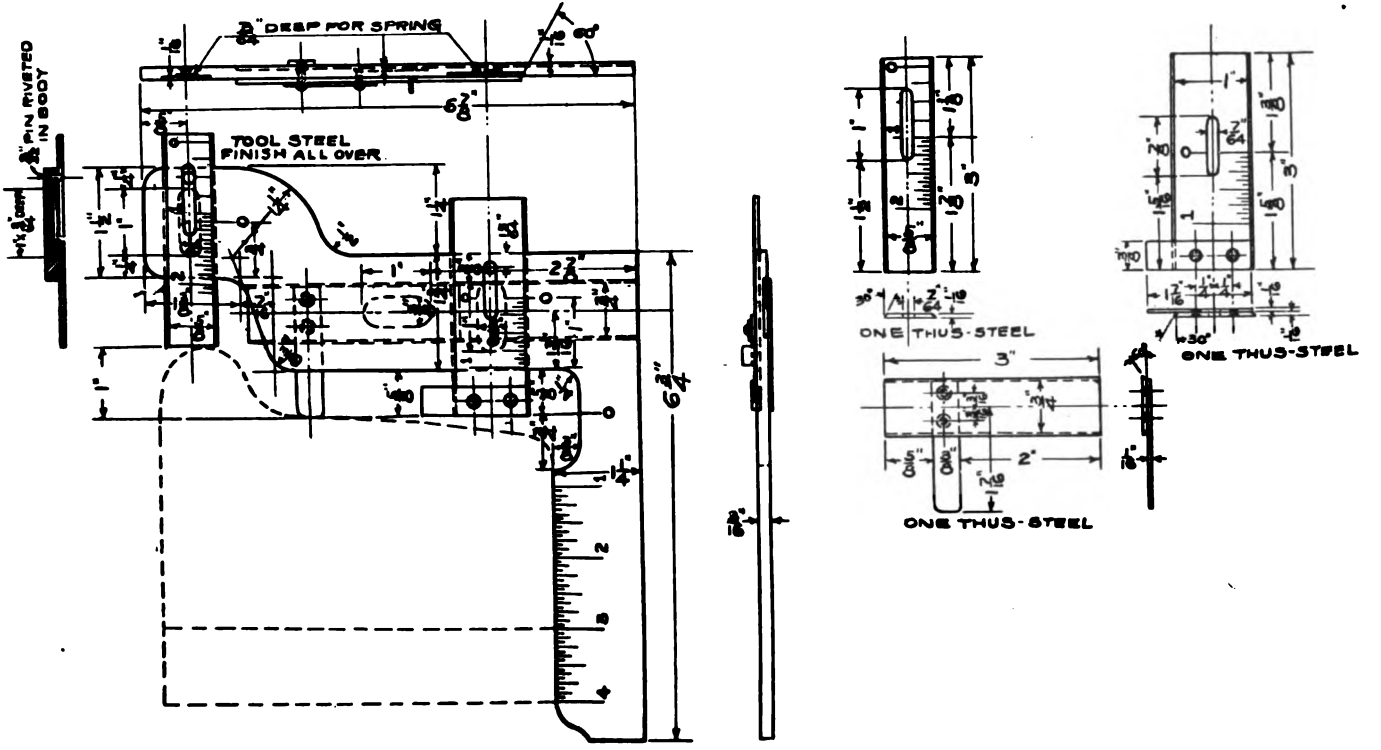


FIG. 6

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TIRE GAUGE

FIG. 7

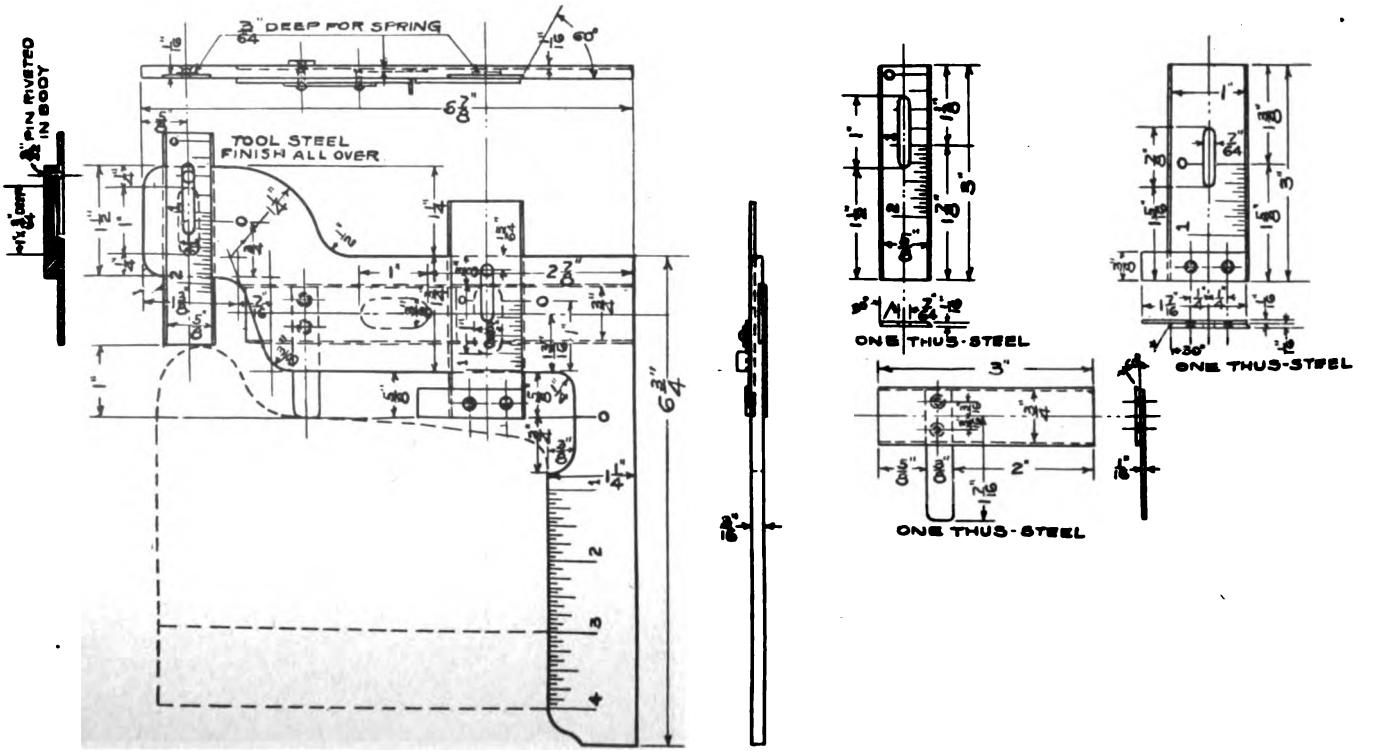


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TIRE GAUGE

FIG. 7



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circumference measure be increased from three to four and the length of the brackets increased so as to project ⅛ inch beyond the rim when brackets are in proper position. The present method of graduating the circumference measure does not provide a definite boundary for each tape size, as the tape sizes are indicated by lines.

It is, therefore, recommended that instead of defining tape sizes by lines they be defined by spaces. Your committee is of the opinion that these changes in the size and number of brackets, as well as the markings of the circumference measure, all of which are shown in Fig. 8, are desirable. As a matter of information, we wish to add that these same changes are among the recommendations of the Standing Committee on Car Wheels to be made to the M. C. B. Association at the 1911 meeting.

RECOMMENDATIONS.

(1) We recommend the M. C. B. 1909 contour as shown in Fig. 1 herewith for all flanged steel or steel-tired wheels, as follows:

(a) Engine truck.
(b) Tender truck.
(c) Driving wheels.
(d) Trailing wheels.

(2) Plain tires to be of three widths, namely, 6 inches, 6½ inches and 7 inches, the contour to be the same as the present standards; the widths of 6¼ inches and 6¾ inches to be eliminated.

(3) Limit of wear of tread or channeling to be as follows: ¼ inch for all locomotive and tender wheels in road service; 5/16 inch for all locomotive and tender wheels in shifting service.

(4) Road limit for driving and trailing wheels to be as specified in chart, Fig. 2.

(5) Road limit for steel and steel-tired wheels for engine and tender trucks to be as per Figs. 3, 4, 5 and 6, which is the 1909 recommended practice of the M. C. B. Association.

(6) Maximum flange height to be 1½ inches.
(7) Gauge to be as per Fig. 7.
(8) Wheel circumference measure to be modified as per Fig. 8.

W. C. A. HENRY, Chairman,
O. C. CROMWELL,
J A. PILCHER,
O. M. FOSTER,
A. C. ADAMS,
Committee.

THE PRESIDENT: If there is no objection we will accept the report and open up the subject for discussion. The recommenda-

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tions will be taken care of by letter ballot, if they are agreed to by the Association.

MR. DUNHAM: I would like to ask if any one has had any particular experience with the 1-inch height of driving-tire flange as indicated in this contour. This is the contour adopted by the Master Car Builders' Association for car wheels. It is quite a different proposition, however, when you come to a driving-wheel contour to take the same height of the flange.

MR. BELL: We are a little at sea. We have been using 1⅛ inches on our driving wheel and engine-truck wheel on high-speed engines, and, in fact, on all engines. We would like to hear some discussion on that matter, and have some of the members who use 1-inch flange on driving wheel and engine-truck wheel, particularly in high-speed service, relate their experience, what success they have had in operating flanges of that height.

MR. BENTLEY: I ask the the members of the Association if any of them have tried ⅞-inch height of flange for switching service only. It has been recommended to us that we use a ⅞-inch flange so as to decrease the amount of wear on the trucks and increase the life of the tires, and I would ask the members of the Association if any of them have used the ⅞-inch flange for switching locomotives only.

MR. GAINES: In reply to Mr. Bentley will say that I have used that ⅞ flange for a long time on several roads, in switching service, and I have never had any trouble. It gives a good flange, and it gives you a chance to wear the tires down, and get more wear, before it is necessary to shift them for a high flange.

MR. JOHNSON: I think Mr. Ettinger of the Southern Road can give us some information on that point.

MR. ETTINGER: A number of years ago, when I was with the C. C. C. & St. L. Ry. we tried some switch engines with ⅞-inch flanges, and they did not stay on the track very well — we had to change them. They were off the track a great deal of the time. That was the only experience I have had with a ⅞-inch flange on driving wheels.

MR. BELL: I might add, Mr. Chairman, that that has been

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our experience. With the 7/8-inch flange we could not keep the switch engines on the track and we had to discontinue using them.

THE PRESIDENT: Any further discussion?

MR. SELEY: I really can not make up my mind to the wisdom of adopting the same contour on these tires as is used in cast-iron wheels. I am not quite sure but that the taper in cast-iron wheels is excessive. With wide track it certainly contributes to derailment by reason of the different circumference. On some types of locomotives, if the tire is brought to this taper it is going to give trouble. When we recently received some new Pacific type engines, there was some complaint that the engines were nosing quite a little. I bided my time and the complaints died out. I believe it was because the tires flattened by wear shortly after they were on the road down to their natural contour, and stopped a great deal of that nosing. The Pacific-type engine is on a pivot, to a certain extent, and I do not like to turn off all of this steel unless there is some good reason for it, and I am rather convinced that for a steel tire the taper is not desirable. Of course, it is necessary in a cast-iron wheel, perhaps, to a certain extent for foundry purposes, but I am not quite sure but what we have gone too far in the Master Car Builders' Association.

MR. PRATT: I was in hope when Mr. Seley started he was going a little further and would suggest that the contour of flange for steel-tired wheel might not be right when it is practically the same as the cast-iron wheel. If we look on page 4, with all the figures of worn tires, we note that there are several flanges 15-16 inches thick after they are worn, and it is presumable that these flanges have not broken. We do not have much experience with broken driving-wheel flanges. Then we look at Fig. 1, which I take it will be the contour of the tires after they are turned up, and imagine how much metal we must turn off to get that flange. I believe there are a good many roads that have a minimum thickness of flange for returned tires, and it seems to me, now that we are after that million dollars a day, we might come out publicly and state what our practice is and adopt a safe course, but not the extreme limit as shown in Fig. 1.

MR. SELEY: I think that is a very good view of the subject

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and this Association as well as the Master Car Builders' Association has got to adopt a different tack. I think it is generally believed that had the safety appliances as required by the Master Car Builders' standards been applied to the cars, we would not have had nearly as much legislation as we have had. A good many of us talked a great deal on the floor, but many of us went back home and did not do what we talked about. I think the standards of this Association as well as the Master Car Builders' Association should be carried out, and if we can not do those things on our railroad that we are doing in the proceedings of the Association we are not at all consistent. I believe that the shop practice, the road practice and the Master Car Builders' standards should all agree.

MR. CURTIS: I am glad to hear this discussion on the height of flange, but I am not ready to adopt the 1-inch height of flange for driving wheel — I might for the tender wheels and engine-truck wheels. I will adopt the 1-inch height for switch service, which we have tried and which has given good satisfaction.

A word in regard to economy has been mentioned here. I will make a citation that 1⅛ inches is the condemning limit for steel-tired wheels for tenders. Switch engines use a large number of tender wheels. In a steel-tired tender wheel 1⅛ inch is not the condemning limit. For switch-engine service this limit can be reduced in some cases to ⅝ of an inch, and by running these wheels under switch engines and making special axles for switch engines, it is not necessary to buy any wheels for switch-engine service on your line. You can always use in the switch-engine service the 1⅛-inch diameter wheels which have been previously in road service. A great many switch-engine tenders will use the M. C. B. 4¼-inch axles, and you might buy the axles with fits as high as 7 inches, and mount the wheel on these same journal axles that have a large fit. In this way you can use the tender wheels or car wheels from all your service, for your switch-engine tenders, and thereby make it unnecessary to purchase any wheels for the switch-engine service. This has been the practice of the L. & N. R. R. for a long time and it works out well.

MR. ROBERT PATTERSON: I am rather surprised that after the years of experience which we have had in turning the tread

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of tires straight that a recommendation like this should come in now. Before my time, that design of turning tires was abandoned. The report does not say what benefit we are to get, from tapering, over our present practice. The only thing I can see is that it is going to make it more difficult to turn the tires, it will take longer to turn them, and they will not be turned as accurately, and it will only be a short time after the engine is running on the road when the tires will come to the natural flat tread the same as we turn them now. This practice was abandoned many years ago, and was abandoned because there was no good purpose served by having the tires turned in that manner, and I would like to know why we should go back to this practice now.

MR. CHAMBERS: I do not know where the last speaker is located, or the road with which he is connected, or how many interlocking plants he has on his system, but I will say if he has as many as there are on the system with which I am connected he will see the benefit of getting the tire tapered. With the tire turned straight, without the taper, we find that there is a great deal of damage done in breaking detector points and other appliances in connection with our interlocking signal systems, and our road adopted four years ago the tapered turn on the tire to avoid interference with the interlocking system.

MR. PATTERSON: Mr. Chambers has evidently misunderstood me in my remarks on this subject. It is quite clear to all of us that the outside edge of tires should be tapered for about 1¾ inches toward the center of tire, so as to clear frogs and switches, but my remarks had reference to the slight taper recommended by the committee from that point to the flange of the tire.

MR. CROMWELL: I can say that the railroad with which I am connected turns the tread of the tire taper for the full width of the tread, to what would amount to 3-16 inch from the throat to the outside of rim. We have been carrying out that practice for about eleven years. We formerly used this practice, and later went to the Master Mechanics' contour, but a very rapid wearing on the tread at the throat of flange took place, rapidly producing thin flanges and grooving, and a reduction in the mileage between tire turnings. After about a year's service under these conditions,

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we again reverted to the previous practice of turning the treads a uniform taper.

When you turn the full taper in the tread, it starts to wear the groove in tread well away from the throat of flange, and thereby increases the mileage between turnings. Prior to the practice of eleven or twelve years ago, at which time the M. M. contour was used, for about a year, a decrease in mileage developed, and was brought to our attention very noticeably by the fact that when we went after the divisional people for not obtaining mileage out of the locomotives, they claimed that it was due to running the tires with the partially cylindrical M. M. tread, which caused thin flanges, and when we went back to the full taper, we again obtained the larger mileage as formerly.

As to the height of flange, I am not much concerned about the 1-inch height of flange giving trouble. On the road with which I am connected we had 1½ inch at one time, but concluded that we would cut it down to 1⅜ inch, which was in time reduced to 1 5-16 inch, later to 1¼ inch, and finally down to 1⅛ inch, and we have not had any more trouble with the latter height than when it was 1½ inch.

MR. BENTLEY: It seems to me that the contour of the tire is going to make a good deal of extra work in the shops. I am glad the subject has come up because it has brought out a number of points the committee will want to look over a little further, and to dispose of the matter I suggest that the committee be continued, and that we suggest to them that they consider some of the points which have been brought up to-day and see if they can not make a report which will more nearly conform to the requirements. I make that as a motion.

MR. PRATT: Does that include further consideration of the minimum flange for return tires?

MR. BENTLEY: I will embody that.

MR. GAINES: I would also venture to suggest that the committee try to get some reports on the actual contour during the year — some reports on the actual result.

MR. BENTLEY: I shall be glad to embody the suggestion in my motion with the consent of my seconder.

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MR. CRAWFORD: I accept it.

THE PRESIDENT: Gentlemen, you have heard the motion, which includes the suggestion of Mr. Gaines, the mover having accepted it. All in favor of the same will say aye; contrary minded, no. Carried.

Mr. Henry, do you wish to say anything further?

MR. HENRY: I would like to say in regard to the height of the flange that for many years one inch has been our standard for engine truck and tender truck, and we never had reason to believe that was in any way objectionable. It has the advantage that, in starting with a short flange, you can get more mileage from the wheel before it reaches the point that necessitates renewal. The height of our flanges on driving wheels of switching locomotives is one inch, that being our standard now for a number of years, having been changed from 1⅛ inches. We find that it has the same advantage as the inch flange on a truck wheel.

In regard to the question of taper, 1 in 20: Our experience has been that the taper gives a longer life to the flange, the tendency being for the flange to run away from the rail. We believe that that has given us more mileage between turning of tires. The advantage that we felt would result from tapering off the outside of the rim was to delay the time when there would be an objectionable amount of guttering of tread. It is true that it means a little more shopwork, but I think if you actually get the cost of your extra shopwork you will find that it won't be worth bothering about.

We have not had any experience with inch-flange driving wheels on road locomotives. I understand that some roads have recently adopted them, and I am also told that they are quite general in European practice.

THE PRESIDENT: The next subject, gentlemen, is the Report on Steel Tires. We have not received a report on this subject for printing, but I understand Mr. Johnson will make a verbal report. I will say for the benefit of the members that Mr. Johnson has been chairman of this committee only a short time and he has not had a full opportunity to investigate this subject.

MR. JOHNSON: Mr. President and Gentlemen, I think it is

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hardly necessary for me to read all of this report that I have here. It is in typewriting, and I will turn it over to the secretary. I will simply give you the report in abstract now.

The following report was presented in abstract by Mr. Johnson:

REPORT OF COMMITTEE ON STEEL TIRES.

To the Members:

Through a chain of unforeseen circumstances, your Committee on Steel Tires was without a chairman until the eleventh hour, and consequently they have not been able to make the thorough investigation into the subject they would have liked to do had there been the whole season ahead of them. Consequently, we practically wish to simply report progress. However, under the circumstances, we have done what we could in collecting specifications already in use, and also information as to the practice on the different railroads in the United States, Canada and Great Britain, on the question of handling the purchase of steel tires for locomotives and cars.

We have communicated with all the large roads on this continent and in Great Britain, and have received some very valuable information, together with specifications already in use, and have drawn up tabulated statements in connection therewith for the information of the members. From a perusal of these statements, it will be noticed that so far as this continent is concerned, purchasing tires by specification is the exception, whereas in Great Britain it is the rule. Where specifications are used in America they are used principally as guides, giving limits in analysis within which the tires should be accepted, and guarding railway companies against accepting tires with facial and contour defects, and we have drawn up for your consideration a specification which, if not entirely satisfactory to the Association in its present form, will at any rate serve the purpose of bringing out a discussion and criticism of its different details, and should the committee be continued for another year it may be possible by the next convention to place before you a specification acceptable to the members.

It is considered advisable by your committee that tires for locomotive service should be purchased in three grades, for passenger, freight and switching purposes.

We feel very strongly the necessity for a physical drop test. We are of the opinion that it is the only true way of knowing exactly what kind of material you have in your tire, as it will show up the result of the working and heat treatment in the manufacture of your tires, which the chemical analysis by itself will not do.

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We also feel very strongly that the test piece for both pulling and analysis should be taken from the tires which have undergone the drop test.

We are including in our report copies of the specifications received from the different railways, at home and abroad, together with synopses of replies to our correspondence.

LACEY R. JOHNSON, Chairman,
J. R. ONDERDONCK,
R. L. ETTINGER,
C. H. HOGAN,
Committee.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

Specification for Steel Tires.

1. *Material.*— Steel for tires shall be made by the open-hearth or crucible process.

2. *Classes.*— There will be three classes of tires for the different classes of service, as follows:

Class 1. Driving tires for passenger engines.

Class 2. Driving tires for freight engines.

Class 3. Driving tires for switching engines and tires for engine-truck, tender-truck, trailer and car wheels.

3. *Chemical Composition.*

CLASS NO. 1.

	Per Cent.
Carbon, not less than	0.50
Phosphorus, not over	0.05
Manganese, between	0.50 and 0.80
Sulphur, not over	0.05

CLASS NO. 2.

	Per Cent
Carbon, not less than	0.65
Phosphorus, not over	0.05
Manganese, between	0.50 and 0.80
Sulphur, not over	0.05

CLASS NO. 3.

	Per Cent.
Carbon, not less than	0.70
Phosphorus, not over	0.05
Manganese, between	0.50 and 0.80
Sulphur, not over	0.05

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4. *Finish.*— The tires must be free from defects of any kind, and finished tires must be accurately machined to the prescribed dimensions of the Master Mechanics' standard, and rough tires must not be outside the limits of the attached print.

5. *Branding.*— The tires shall be distinctly stamped when hot with such brands as the purchaser may require, and in such a manner that these marks shall be legible when the tires are worn out.

6. *Samples for Chemical Analysis.*— Drillings from a small test ingot, cast with the heat or turnings from a tensile specimen or turnings from a tire (where tires are machined at the works of the manufacturer), shall be used to determine whether the chemical composition of the heat is within the limits specified in paragraph 3.

When required, the purchaser or his representative shall be furnished an analysis of each heat from which tires are made.

7. *Physical Properties.*— The steel for the different classes of service shall meet the following minimum physical requirements:

Class.	Tensile Strength, Lbs. per Sq. Inch.	Elongation, Per Cent in 4 Inches.
(a)	105,000,	quotient of 1,550,000 ÷ Tensile strength.
(b)	115,000,	quotient of 1,300,000 ÷ Tensile strength.
(c)	125,000,	quotient of 1,150,000 ÷ Tensile strength.

8. *Falling-weight Test.*— A test tire from each heat represented shall be selected by the purchaser or his representatives, and furnished at his expense, provided it meets the requirements.

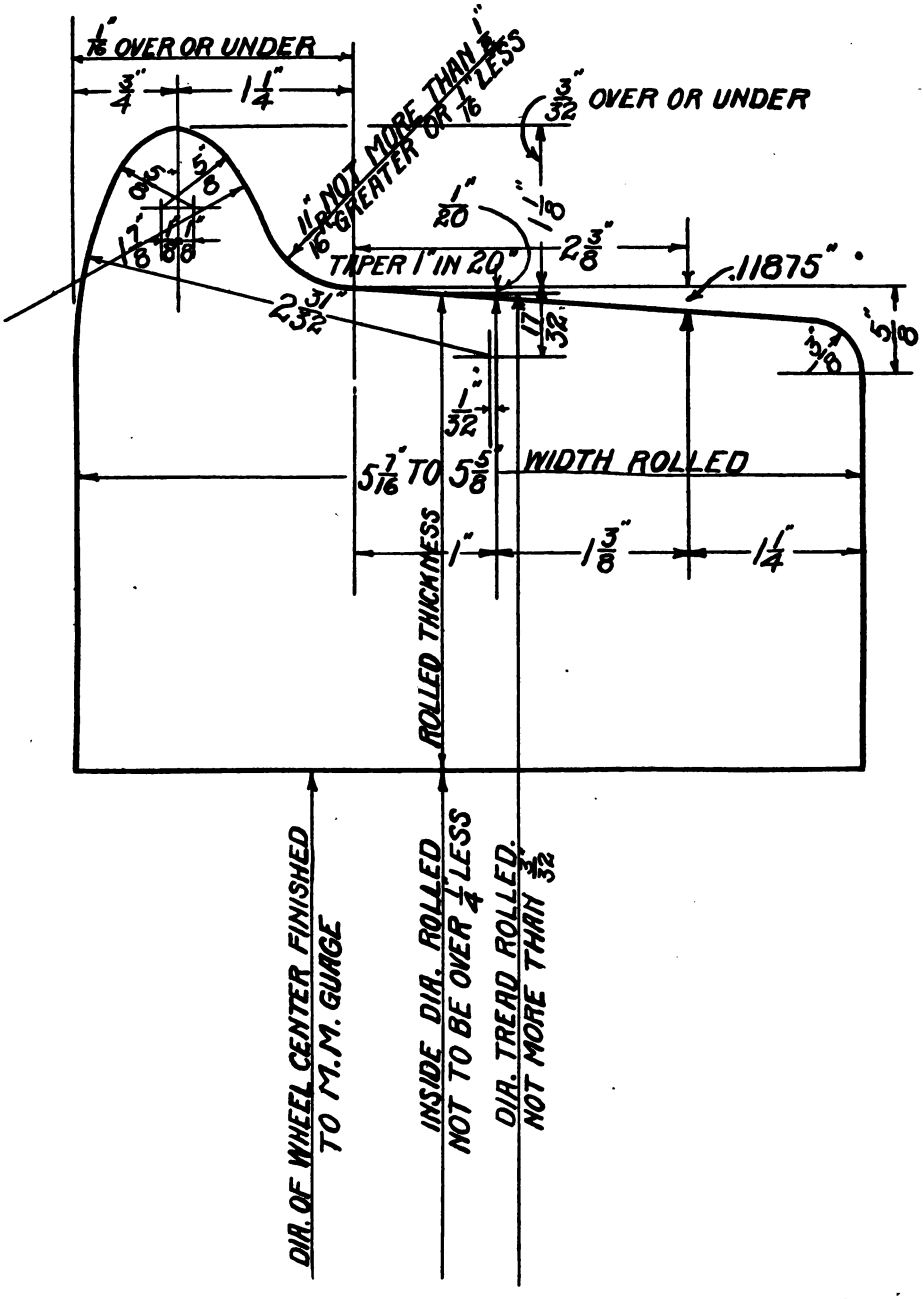
8. (a) The test tire shall be placed vertically under the drop in a running position on a spun foundation with an anvil of at least 10 tons weight, and shall be subjected to successive blows from a tup weighing 2,000 pounds, falling from heights of 10 feet, 15 feet, and 20 feet and upward, until the required deflection is obtained as specified in paragraph 8 (b).

8. (b) The test tire shall stand the drop test prescribed in paragraph 8 (a) without breaking or cracking, and shall show a minimum deflection, and it is hoped to present a formula covering this point at the next meeting.

8. (c) A specimen for the tensile test is to be taken from a tire that has been subjected to a falling-weight test, and it shall be cut cold from the tested tire at the point least affected by the falling-weight test. The tensile-test specimen, when cut from a tire that has been subjected to a falling-weight test, shall be cut normal to the radius and parallel to the face.

8. (d) Should the test tire fail to meet the requirements in any particular, two more test tires shall be selected from the same heat if the

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THE PLAIN TIRES HAVE THE SAME LIMITS UNDER AND OVER NORMAL DIMENSIONS AS HAVE THE FLANGED TIRES.

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manufacturer so desires, and at his expense. Should these two tires fulfill the requirements, the heat shall be accepted.

9. *Inspection.*— The inspector representing the purchaser shall have free entry to the works of the manufacturer at all times while his contract is being executed. All reasonable facilities shall be afforded to the inspector by the manufacturer to satisfy him that the tires are being furnished in accordance with the specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

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QUESTIONS ASKED THE DIFFERENT RAILROAD COMPANIES, WITH TABLE SHOWING THEIR REPLIES.

QUESTION No. 1.—Supply copies of any specification for passenger, freight and switching engines which may be in use on your road, or give suggestions for any points you consider advisable to embody in a specification.

QUESTION No. 2.—Have you any branch or branches running north and south? If so, do you make any difference in your specification or analysis for tires for service in the north and south to meet climatic conditions?

QUESTION No. 3.—If a physical drop test is specified, what class of test would you recommend as best showing the quality and condition of the tire?

QUESTION No. 4.—Are you prepared to face the responsibilities of living up to the specification?

NAME OF RAILWAY COMPANY.	ANSWER TO QUESTION No. 1.	ANSWER TO QUESTION No. 2.	ANSWER TO QUESTION No. 3.	ANSWER TO QUESTION No. 4.
Baltimore & Ohio R. R. Co.....	Specification attached.	Yes; but make no difference.....	No drop test.....	Yes.
Canadian Pacific Ry.....	Specification attached.	No; east and west line.	Krupp, Monkbridge & Vicker's tires, tensile test; Steel - Peach tire, drop tested....	Yes.
Erie R. R. Co.....	Specification attached.	Yes; but make no difference.....	No drop test.....	Yes.
Great Northern Ry. Co.....	Specification attached.	Yes; but make no difference.....	No.....	.....
Michigan Central R. R. Co.....	Specification attached.	Yes; but make no difference.....	No.....	.....
Southern Pacific R. R. Co.....	Specification attached.	Yes; but make no difference.....	No; tensile test only, and analysis.....	Yes.
Union Pacific R. R. Co	Specification attached.	Yes; but make no difference.....	No drop test.....	Yes.
Lehigh Valley R. R. Co.....	Now revising specification, but not decided on full details yet...	No.....	No.....	Yes.
Atlantic Coast Line R. R.....	Have no specification.	.....	.....	.....
Pennsylvania R. R. Co.....	Have no specification.	Same kind of tires used on all divisions.....	No tests made.....	.....

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NAME OF RAILWAY COMPANY.	ANSWER TO QUESTION No. 1.	ANSWER TO QUESTION No. 2.	ANSWER TO QUESTION No. 3.	ANSWER TO QUESTION No. 4.
Pere Marquette R. R. Co.....	Have no specification.	Same kind of tires used on all divisions.....	No.....	.....
Rock Island Lines.....	Have no specification.	Same kind of tires used on all divisions.....	No tests.....	.....
St. Louis & San Francisco R.R. Co.	Use manufacturers' specifications.....	Same kind of tires used on all divisions.....	.....	.....
Illinois Central R. R.....	Have no specification.	No distinction in tires.	No tests.....	.....
Mobile & Ohio R. R.....	Have no specification.	Same tires on all divisions.....	No tests.....	.....
Atchison, Topeka & Santa Fe Ry.	Use manufacturers' specifications.....	Same tires on all divisions.....	No data of tests.....	Not yet.
Chicago, St. Paul, Minneapolis & Omaha R. R.....	Specification attached.	Same tires on all divisions.....	No physical test required.....	Makers stand by specification.
London & North Western Ry. (England).....	Use British standard specification.....	No difference for the different sections...	.....	Driving wheels for goods engines made of denser steel. No difference in other tires.
London & South Western Ry. (England).....	Specification attached.	.....	Falling weight test....	For all class tires.
South Eastern & Chatham R. R. (England).....	Specification attached.	No difference.....	Falling weight test....	For all class tires.
Great Western Ry. (England)....	Specification attached.	No difference.....	Falling weight, tensile and ringing tests...	Specification strictly adhered to.
Great Central Ry. (England)....	Specification attached.	No difference.....	.....	.....
Great Eastern Ry. (England)....	Specification attached.	No climatic difference; two classes of tires..	No physical drop test.	Specification strictly observed.
Great Northern Ry. (England)...	British standard specication attached....	No climatic difference; two classes of tires..	Drop test.....	Yes.
Intercolonial Ry. of Canada.....	Specification attached.	No difference.....	Drop test suggested...	Yes; as far as physical tests are concerned.

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QUESTIONS ASKED TIRE MANUFACTURERS.

QUESTION No. 1.—Do you think it fair for a superintendent of motive power to draw up a specification, and then, after the tires are supplied to that specification, hold the manufacturers responsible for the results?

QUESTION No. 2.—Do you feel the interests of the motive power officer would be well served by their issuing a specification as outlined above, or do you think it would be better to leave the chemical analysis and the working of the tire in the hands of the manufacturers?

QUESTION No. 3.—Would you suggest using a different composition for passenger, freight and switching engines, and further, have you experimented with different proportions of manganese in the steel, and, if so, what do you find about the maximum percentage of manganese which can be introduced into the steel without making the tires unworkable in the boring and turning mills?

NAME OF MANUFACTURING COMPANY.	ANSWER TO QUESTION No. 1.	ANSWER TO QUESTION No. 2.	ANSWER TO QUESTION No. 3.
Taylor Bros. & Co., Ltd., Leeds	Not advisable to tire makers.	Leave to manufacturers	One class tire only. Manganese less than 1 per cent.
Steel, Peach & Tozer	Not fair to tire makers	Future orders should be dependent on results	One class tire only; best tire only on each class engine. About .80 manganese.
The Monk Bridge Iron & Steel Co., Leeds	No	Leave composition to the makers	Same composition for all classes. Manganese .7 to .9 per cent.
Standard Steel Works Co. of Philadelphia	Responsibility should be on party drawing up specification	No	Same composition for three classes. Manganese not more than .75.
The Midvale Steel Co	No	Makers should be guided by their own judgment	Same composition, but for freight and switchers made a little harder.
Thos. Firth & Sons, Ltd., Sheffield		Leave this to the makers	One class tire only. Manganese .70 to 1 per cent.
Krupps	No	Leave this to the makers	Not necessary to use different grades of steel for different classes of engines.

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THE PRESIDENT: Gentlemen, unless there is objection — and the Chair hears none — the report will be accepted. The report is now open for discussion. I want to take this opportunity to personally thank Mr. Johnson for what he has accomplished in the exceedingly short time during which he has had this work in hand.

MR. SELEY: I am personally opposed to the destructive test if it can be avoided. It seems to me that in the matter of tires we ought to hesitate a long time before adopting, or even considering, destructive tests. While with a large order of locomotives one might be able to justify the cost of such tests I do not believe that is true of a majority of tire purchases. A great many roads buy a limited number of sets of tires at a time; and I rather think, without going into any calculation, that it would require a pretty good sized order to justify the cost of the waste of material in a destructive test. I do not wish, however, to discourage the committee. Nevertheless, I think they ought to have this thought in mind.

MR. FOWLER: I think it well to suggest to the committee that it would be interesting to the members of the Association for the present year if they would give the reasons why they recommend three kinds of tires for three services, running the carbon up from 50 to 70 in the three types of tire involved?

MR. BENTLEY: I think if the committee can work up a specification that will enable a manufacturer to produce a tire that will not shell out under engine, tender or car, they will confer a lasting benefit upon the members of this Association. It is getting to be a serious matter the way in which steel-tired wheels fall down in service. At one time we were in the habit of taking up the matter with the manufacturers and telling them, "We have some steel tires that are very badly shelled, and we would like to have you look at them and make arrangements to replace them," and they were quite willing to do it; but apparently they have overcome that disposition and gotten together now, and none of them will replace a shelly tire, and they take the position that it is the service that we give it and not the material in it that caused the tire to shell. Now it seems to me it is up to the manufacturers to make a tire that will stand the service that we require of it.

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Some of the manufacturers contend that it is due to sliding. I have personally shown them tires where on one side there was a shelly condition extending for 14 to 16 inches around the tread and on the other side there was no indication whatever of sliding. Hence, I do not think that point is well taken, especially when the defects will penetrate a tire a depth of from ¼ to ⅝ of an inch. I would like to know whether other members here have had a similar difficulty, and, if so, can they recommend anything to overcome it.

MR. CURTIS: I certainly hope Mr. Johnson will answer the inquiry why the committee recommend three kinds of tires for three services.

I agree with Mr. Seley in what he has said respecting the destructive test. The Louisville & Nashville R. R. has over nine hundred locomotives in use, and the tire breakage is practically nil. I do not think we have a tire break once in a year. I think that is due to the climate perhaps, because roads in colder climates have more breakage. We have purchased tires from all of the leading manufacturers, and our experience has been pretty much the same with them all.

MR. FOWLER: In answer to the suggestion of Mr. Bentley I would say that a few years ago I had the opportunity of making some elaborate investigations in regard to steel tires. I was about two years collecting samples of tires, from various parts of the country, that had shelled out. I had the assistance of the New York Central, the Erie and the Pennsylvania Lines in picking out tires with the idea of determining if possible what was the cause of the shelling. I had a large number of tires that were shelled out, and I made a very careful examination and investigation to ascertain the cause of the defect. I cut down through the shelled-out portion of the tire where the defect was very apparent, and then on the other side of the tire, and took out the best parts or pieces of the metal that I could find. I found that in all the tires I examined the cause of the shelling out was simply slag. These tires were picked out haphazard by the three roads I have mentioned. Clean metal would probably have prevented that particular shelling. I am very far from saying or believing that slag is the only cause of shelling out, for there may be many of these,

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but, as I say, that was the only thing that I succeeded in finding in the tires which I examined.

MR. GAINES: So far this morning we have only brought up the question of shelled-out spots in the treads. Lately I ran into a little difficulty, especially on the rolled solid wheel, with the flange cracking down toward the hub of the wheel. I would like to suggest to the committee that they endeavor to find some remedy for that defect. The makers claim it is due to brake burn because of the character of the brake shoes.

THE PRESIDENT: Have you used flange brake shoes?

MR. GAINES: Yes, but lately we have gone to a semiflange shoe, and still have the trouble.

THE PRESIDENT: We had considerable trouble of that nature and the wheel manufacturers claimed it was due to the flanged shoes. We changed to the semiflange shoe, having an inch and a half flange at each end, but we have had almost the same trouble. My observation is that with a built-up wheel we have not had very much trouble due to flange cracking. We have taken the position that it is the fault of the wheel manufacturer and not the fault of operating conditions. We would also endorse the position taken by Mr. Bentley. I think this resolves itself into a question of manufacturers being able to make a wheel that will stand the present-day service regardless of conditions, except, of course, abuse.

MR. FOWLER: They had identically that same trouble in Brooklyn in the rapid-transit service on the elevated road, using a flange shoe. There were vertical cracks down through the flange of the wheel. They came to the conclusion there that it was a manufacturer's defect, and upon carefully cutting out those wheels and looking them over critically under the microscope we discovered evidences that the trouble was caused by a heat crack due to some process in the rolling of the wheel. That is the position assumed and maintained by the railroad company.

THE PRESIDENT: Are there any further remarks on this subject?

MR. ANGUS SINCLAIR: I move that the committee be continued.

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MR. BENTLEY: I second that motion.

THE PRESIDENT: All in favor of continuing the committee will signify the same by saying aye; contrary, no.

Carried. It is so ordered.

MR. JOHNSON: Before passing from this subject may I say one or two words in regard to the inquiry put by Mr. Seley?

THE PRESIDENT: Certainly.

MR. JOHNSON: As to the destructive test I would say that this specification was laid before the convention more for the purpose of eliciting suggestions. It was thought that it would bring forth a whole lot of discussion and that the various details might be worked out hereafter. We felt very strongly that it was necessary to have such a test for the reason that we give in the report, namely, that it is the only true way of noting exactly what kind of material is in the tire when delivered, because it will show up the result of the working and the heat treatment in the manufacture of the tire which a chemical analysis by itself will not do. For instance, you can take an ingot which will pass a good chemical analysis, and yet that same ingot can be destroyed by its after treatment in the process of manufacture.

A question was brought up in regard to the three different grades of tires. The reason for making that suggestion was not that we should have a good class of tire for one particular service and an inferior class of tire for another so much as that we could use a very much harder steel for freight service than we could for fast passenger service, and consequently get a correspondingly longer life to it. It was not that there should be any difference in the actual quality of the metal.

In regard to the shelling out of tires: I suppose there is hardly a railroad that has not had more or less experience of that kind, but the chemical analysis which has been used by the Baltimore & Ohio for some years now has practically eliminated that trouble and shelled-out tires are now unknown there.

THE PRESIDENT: The next subject, gentlemen, is Flange Lubrication. Mr. Haig is the chairman of this committee and will present the report.

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MR. HAIG: Mr. President and Gentlemen. The report is in print, and I will not read it in full, but will simply refer to certain portions of it.

The types in passenger service are the Pacific and the Consolidation in freight service upon which flange wear is most prevalent. However, where types are employed with a longer wheel base than the Consolidation these are reported as being subject to the greatest flange wear. In general, if other conditions are equal it is the type with the longest rigid wheel base on which flange wear is the greatest. There are some notable exceptions to this rule, however, in passenger service.

There are two classes of expense due to excessive flange wear. One results from the metal lost in producing standard flanges after they have been badly worn. The other is due to the loss of revenue and the cost of repairs when necessary to turn or remove tires between regular shoppings of the engine.

On page 4 the report refers to the total mileage obtained during the life of a set of tires and there are two figures shown. Also on page 5 is a table showing the loss of tire mileage due to excessive flange wear. Also a very interesting table on page 7.

There are four types of lubricators designed to use asphaltum base crude oil. These are the Chicago, the Southern Pacific, the Canadian Pacific and the Rock Island. Where no other name is known, that of the railroad upon which the lubricator has been developed is used.

There are two lubricators in use employing a lubricant in a solid form: the Collins and the Turnbull. There are cuts showing these lubricators at pages 14 and 15.

Crude oil is now in general use for flange lubrication on the Santa Fe system. There are no data on the Santa Fe to show the exact increase in the life of rails on curves effected by the flange oilers. On the New Mexico Division with one hundred per cent of the locomotives equipped, it has been estimated that there has been an increase of about two months in the life of rails, that previously required changing about every thirteen months. This is an increased life of fifteen per cent. In territories where no figures are available, it is, however, the opinion of all officials that the flange oilers have materially decreased rail wear.

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On several pages of the report there are references to the economy attained on different railways.

I feel that most of the information is covered in this report, gentlemen, and in the illustrations and tables to be found in it, and therefore I do not think that a further statement of the report is necessary. I submit the report.

The report submitted by Mr. Haig is as follows:

REPORT OF COMMITTEE ON FLANGE LUBRICATION.

To the Members:

It has been the purpose of your committee appointed to report on flange lubrication to obtain sufficient information to determine, (1) to what extent trouble from flange wear is experienced, (2) the lubricants and means of applying them which are in use and (3) the effectiveness of lubrication in overcoming flange wear and its attendant evils. A circular of inquiry was issued and the committee's report is based upon the replies received from motive-power officials of about thirty railroads representing widely different grade, curvature and weather conditions of operation. The committee, therefore, feels justified in looking upon a synopsis of these replies as indicative of the flange-wear situation and, in general, the effectiveness of lubrication.

Among the detailed replies to the committee's circular, two only indicate that the officials represented are not having trouble in their territory from flange wear. In addition, five replies state that lubricators are being used or experimented with, which indicates trouble from this source. Eight answers on the other hand state that the railroads represented have no lubricators in use, and, unfortunately, no statements are made as to flange-wear conditions. Among these are the Erie, in the East, and the Great Northern, in the West, both of which pass through a mountainous territory, and, therefore, have a large number of curves to contend with. The Erie, however, is investigating with a view to adopting flange lubrication, a fact which would indicate that it is experiencing some trouble due to flange wear.

The Lake Shore & Michigan Southern Ry. reports having no trouble with road engines, but in some yards the wear on driving-wheel flanges of six and ten wheel switch engines becomes a very serious matter. The Santa Fe has had the same experience with six-wheel switch engines where a large percentage of the total mileage is made on curved track.

The railroads reporting flange wear are shown in Table I, together with maximum curvature and grade conditions and the locomotive types

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most affected. This table presents a review of the flange-wear situation as complete as the data at hand will permit.

It will be noticed that with one exception the curvature reaches a maximum of six degrees or more. It would seem, however, that the mileage of curved track relative to total mileage would produce more effect on flanges than the degree of curvature alone. There are a number of other conditions affecting flange wear; among them are length of rigid wheel base, speed, lateral movement and tire spacing, and the degree of stiffness of engine truck.

Table II presents a list of railroads reporting, the locomotive types employed on these railroads and the locomotive types having greatest flange wear. The locomotive types reported in service on each railroad are designated by crosses (×), marked in the lines opposite the initials of the railroad and in the columns headed by the locomotive types.

Pacific in passenger service and consolidation in freight service are the types on which flange wear is most prevalent. However, where types are employed with longer wheel base than the consolidation, these are reported as being subject to greatest flange wear. In general, if other conditions are equal, it is the type with longest rigid wheel base on which flange wear is greatest.

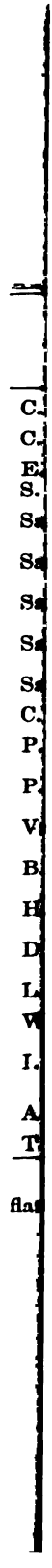
There are some notable exceptions to this rule in passenger service. One division of the Pennsylvania Railroad with engines of the Pacific type in service reports greatest flange wear on those of the Atlantic type. This is also the case on the Eastern Lines of the Santa Fe System. While there is no statement to this effect, this condition may be due to the Atlantic type operating on a section of the road more severe on flanges because of excessive curvature.

There are two classes of expense due to excessive flange wear. One results from the metal lost in producing standard flanges after they have been badly worn and the other is due to the loss of revenue and the cost of repairs when necessary to turn or remove tires for flange wear between regular shoppings of the engine.

The figures covering metal loss have been presented according to different standards and it is, therefore, difficult to compare them. In some instances, the loss has been measured in radial thickness of tires, in others by weight per turning, and in still other cases by the value of metal turned off. Where stated in radial thickness, the amount varies between ¼-inch and ¾-inch. Loss in weight is stated as varying between 55 pounds and 1,150 pounds per engine per turning, depending upon the number of wheels and the extent of flange wear. The loss of metal expressed in terms of money value for engines of various types is given as follows: Four-wheel switch, $45; six-wheel switch, $50; standard, $50; ten-wheel, $50; consolidation, $60; Mallet, $90.

The total mileage obtained during the life of a set of tires appears to be the most satisfactory measure of tire service. On this measure as a

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TABLE II.

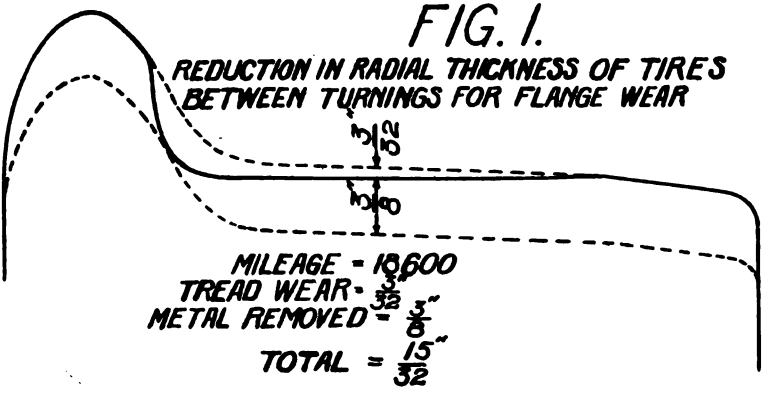
LOCOMOTIVE TYPES IN SERVICE AND TYPES HAVING GREATEST FLANGE WEAR.

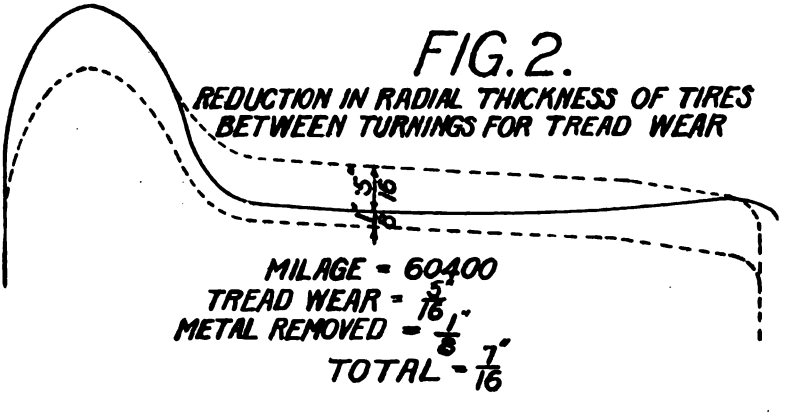
RAILROAD.	TYPES IN SERVICE.											GREATEST FLANGE WEAR.						
	4–4–0.	4–4–2.	4–6–0.	4–6–2.	2–6–2.	2–6–0.	2–8–0.	2–8–2.	2–10–0. 2–10–2.	Switch.	Mallet.	4–4–2.	4–6–0.	4–6–2.	2–8–0.	2–10–2.	Switch.	Mallet.
C. R. I. & P.	....	....	×	×	....	....	×	....	....	....	....	....	....	....	×	....	....	....
C. P.—Lines West.	×	....	×	×	....	....	×	....	....	....	....	....	....	....	×	....	....	....
E. P. & S. W.	....	....	×	×	×	....	×	....	×	....	....	....	....	....	....	....	....	....
S. P.—Salt Lake Division	....	....	....	×	....	×	×	....	....	×	....	....	....	×	....	....	....	....
Santa Fe—Coast Lines.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	×	....	....
Santa Fe—New Mexico Division	....	....	....	×	....	....	×	....	×	....	....	....	....	×	....	....	....	....
Santa Fe—South West Lines.	×	×	×	....	×	×	....	....	....	....	....	×	....	....	....	....	....	....
Santa Fe—Gulf Lines.	×	....	×	×	....	....	×	....	....	....	....	....	....	×	×	....	....	....
Santa Fe—East Lines	×	×	×	×	×	....	....	....	....	×	....	×	....	....	....	....	....	....
C. & S.—Narrow Gauge.	....	....	....	....	....	×	....	....	....	....	....	....	....	....	....	....	....	....
P. R. R.	×	×	....	×	....	×	×	....	....	....	....	×	....	....	×	....	....	....
P. R. R.—West Penn. Division	×	×	×	×	×	×	×	....	....	×	....	....	....	×	....	....	×	....
*Vandalia.	×	×	×	×	....	×	×	....	....	×	....	....	....	....	....	....	....	....
B. & L. E.	....	....	×	....	....	×	×	....	....	×	....	....	....	....	×	....	....	....
*H. V.	....	....	....	....	....	×	×	....	....	....	....	....	....	....	....	....	....	....
D. & H.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	×	....	....	×
L. S. & M. S.					All Types.							....	....	....	....	....	×	....
W. P. T.	×	....	×	....	....	....	×	....	....	×	×	....	....	....	....	....	....	....
I. C.	×	×	×	×	....	....	×	....	....	×	....	....	....	....	....	....	×	....
A. B. & A.	....	....	×	....	....	....	....	×	....	×	....	....	....	....	....	....	×	....
T. R. R. Ass'n. of St. Louis.	....	....	....	....	....	....	....	....	....	×	....	....	....	....	....	....	×	....

*Very little difference in flange wear observed on types in service.

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basis, the estimate presented in Table III has been prepared to show the loss due to turning tires on account of flange wear compared with the total mileage during the life of tires when turned for tread wear. It represents the service obtained from Atlantic type locomotives operating on the Missouri Division of the Santa Fe. The mileage between tire turnings is computed from the average mileage per locomotive per month and the time between turnings; the average mileage per locomotive per month was obtained from records of twenty locomotives over a period of eight months. Before lubricators were applied, these locomotives averaged 18,600 miles between tire turnings before reaching the limit of 1-inch vertical flange wear. Since the adoption of flange lubrication, the same locomotives average 60,400 miles between tire turnings for tread wear. Figs. 1 and 2 graphically illustrate the method of arriving at the aggregate loss given in Table III. In Fig. 2 is shown the condition of tires with $\frac{5}{16}$-inch tread wear after making 60,400 miles. To facilitate proper turning, $\frac{1}{8}$-inch is





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usually removed in the lathe. The total reduction in radial thickness between successive tire turnings will, therefore, amount to 7/16-inch. Fig. 1 illustrates the condition of tires when the locomotive is shopped because of sharp flanges after making only 18,600 miles.

TABLE III.

LOSS OF TIRE MILEAGE DUE TO EXCESSIVE FLANGE WEAR.

4–4–2 Type, operating on Missouri Division, A. T. & S. F. Ry.:

Mileage between turnings—Flange Wear (7/8" to 1" vertical)	18,600
Mileage between turnings—Tread Wear (5/16" maximum)	60,400

Flange Worn	Metal removed to build up standard flange	3/8"
	Tread Wear (Rate 5/16" per 60,400 mi.)	3/32"
	Total reduction in radial thickness between turnings	15/32"
Tread Worn	Metal removed (To facilitate turning)	1/8"
	Tread Wear	5/16"
	Total reduction in radial thickness between turnings	7/16"

FLANGE WORN TIRES.		TREAD WORN TIRES.	
Thickness of Tire.	Average Mileage.	Thickness of Tire.	Average Mileage.
New, 3 1/2"		New, 3 1/2"	
After first turning, 3 1/32"	18,600	After first turning, 3 1/16"	60,400
After second turning, 2 31/32"	18,600	After second turning, 2 5/8"	60,400
After third turning, 2 3/32"	18,600	After third turning, 2 3/16"	60,400
Scrap	18,600	Scrap	60,400
Estimated total	74,400	Estimated total	241,600

Total loss of mileage during life of tires	167,200
Loss, per cent, "–69–"	

That this estimate may be conservative, a very liberal curve has been assumed at the throat of the worn flange. In order to reproduce the standard tire contour it is necessary to turn off 3/8-inch of metal from the tread. The total reduction in radial thickness between tire turnings is 15/32-inch, which is 1/32-inch greater than the total shown in Fig. 2. Assuming a minimum thickness at the last turning of 2 inches, the difference in total mileage during the life of tires under the two sets of conditions is 167,200, a loss in tire service of 69 per cent due to flange wear.

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TABLE IV.

Loss of Revenue and Cost of Labor Due to Flange Wear.

Railroad.	Time Out of Service when Shopped for Sharp Flanges.	Loss of Revenue.		Labor Charges.			
		Per Day.	Per Shopping.	To Change Tires.		To Turn Tires.	
C. R. I. & P.	2 days.	$20.00	$40.00	4–6–2..	$15.00	4–6–2..	$ 7.00.
				2–8–0..	20.00	2–8–0..	8.00.
C. P.—Lines West.				*.	8.00	2–8–0..	3.00.
E. P. & S. W.						2–8–0..	4.20.
						4–6–2..	3.15.
S. P. —Salt Lake Div.	**			2–8–0..	15.00	2–8–0..	4.00.
A. T. & S. F.	††5 to 30 hours.	$25.00	$5.00 to 35.00.	4–4–2..	3.00	4–4–2..	3.35.
				2–10–2.	7.00	2–10–2.	8.28.
P. R. R.	18 to 20 hours..	$39.00	About $30.00..	4–6–2..	30.92	4–6–2..	33.77.
				2–8–0..	20.96	2–8–0..	21.64.
P. R. R.—W. Penn. Div.	24 hours up.	$2.50 per hour.	$60.00 up.	4–6–2..	28.05		
				2–8–0..	26.66		
Vandalia.	2 or 3 days.			4–6–2..	6.30–19.80	4–6–2..	6.40.
				2–8–0..	8.40†	2–8–0..	6.72.
B. & L. E.	To turn–60 h'rs. To change—12 hours.	$25.00	$62.00	4–6–0..	13.32	4–6–0..	4.10.
			$12.00	2–8–0..	18.00 to 20.00	2–8–0..	5.20.
H. V.	6 days.		$66.00				
D. & H.	24 hours.	Varies.		4–6–2..		4–6–2..	$2.10 to $2.70
				2–8–0..		2–8–0..	2.80 to 3.60
L. S. & M. S.	Shop—10 hours R. House—2 d's	Capital charges only.		–006–..	6.00	0–6–0..	$12.00.
W. P. T.	10 days.	$11.00	$110.00	Mallet.	90.00	Mallet..	90.00.
I. C.	24 hours.	$10.00 to 15.00	$10.00 to 15.00	0–6–0..	15.50	2–8–0..	2.92.
				2–8–0..	24.00	4–6–2..	2.88.
				4–6–2..	30.00		
A. B. & A.	5 or 6 days.	‡$82.00	$410.00 to 492.00	4–6–0..	11.40		10.00.
				0–6–0..	13.68		
T. R. R. Ass'n of St. Louis.	2 or 3 days.			0–6–0.	13.80	0–6–0..	4.80.

*Two pairs of tires exchanged.
†$19.80 for 4–6–2 type with retaining rings.
‡Based on gross earning capacity.

**No engines shopped because of sharp flanges.
††Depending upon number of wheels and whether tires are replaced by others or same tires are turned and replaced.

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TABLE VI–A.

ESTIMATED SAVING BY USE OF DRIVER FLANGE LUBRICATORS ON FORWARD DRIVERS OF MOUNTAIN ENGINES, SOUTHERN PACIFIC.

1.	Total mileage of ten selected engines before application of flange lubricators; from January 1, 1906 to date of application	629,703
2.	Total cost of tire attention, from January 1, 1906 to date of application of flange lubricators.....	$6,108.00
3.	Cost of tire attention per mile run, before application of flange lubricators.....	$.0097
4.	Number of times tires were changed from January 1, 1906 to date of application of lubricators, including tire turning.....	71
5.	Average mileage per change of tire, before application of lubricators.....	8,869
6.	Total actual mileage of ten selected engines since application of flange lubricators.....	421,513
7.	Average mileage per change of tire since application of flange lubricators.....	42,151
8.	Cost of tire attention per mile run after application of flange lubricators.....	$.002041
9.	Percent of increase in mileage per change of tire.....	375
10.	Percent of decrease in cost of tire attention per mile run.....	79

69 CONSOLIDATION ENGINES.	Average Mileage per engine per month.	Total Mileage per Year.	Cost per Mile Run.	Total Cost of tire attention One Year's Service.
Before application.....	2491	2,062,548	$.0097	$20,006.72
After application.....	2635	2,181,780	.002041	4,453.01
Estimated saving effected on mileage obtained with flange lubricators based on cost per mile before use of same.....	.....	2,181,780	$.007659	$16,710.25

The loss of revenue and the expense of turning and changing tires when locomotives are taken out of service because of worn flanges is shown by Table IV. The experience of several different railroads is given and the data presented are as complete as it has been possible to obtain. In some instances, where flange wear is excessive, when the front pair of tires becomes badly flange worn, it is removed and exchanged with another pair from the same locomotive. On locomotives with four pairs of drivers, two shifts may be made. But under severe conditions, it is impossible by this means alone to keep locomotives in service until the tires become tread worn. In Table VI-A, showing the estimated saving due to the use of

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flange lubricators on the Southern Pacific, the average mileage per change of tires necessitated by flange wear is given as 8,869. The practice was to make two shifts of tires before turning. Computed on this basis, the mileage between successive turnings for flange wear is only 26,607, while tread-wear mileage obtained since the application of lubricators is 42,151.

Since the increasing prevalence of flange wear has been forcing it to the attention of motive-power officials, many methods of lubrication have been applied in the effort to overcome this evil. Fourteen different forms of lubricators are now in use or have been tried by the railroads reporting to the committee. These may be grouped according to the kind of lubricant used into the following classes: (1) crude oil; (2) engine and car oil; (3) solid lubricant; (4) water; (5) exhaust steam.

There are four types of lubricators designed to use asphaltum base crude oil. These are the Chicago, the Southern Pacific, the Canadian Pacific and the Rock Island. Where no other name is known that of the railroad upon which the lubricator has been developed is used.

The Chicago Flange Oiler is designed to meet the requirements of the Elliott system of lubrication, which embodies a sight-feed oiler located on the back boiler head and a delivery pipe on each side of the engine leading

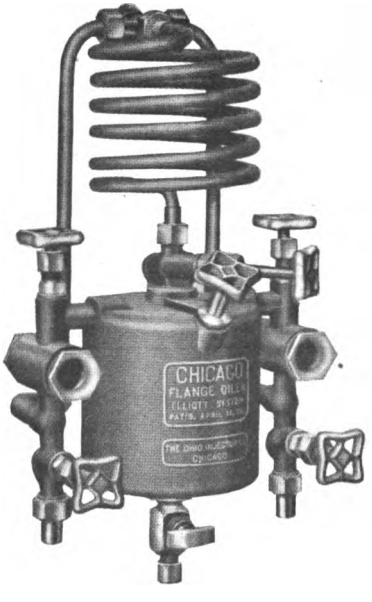


FIG. 3.— HYDROSTATIC FLANGE OILER.

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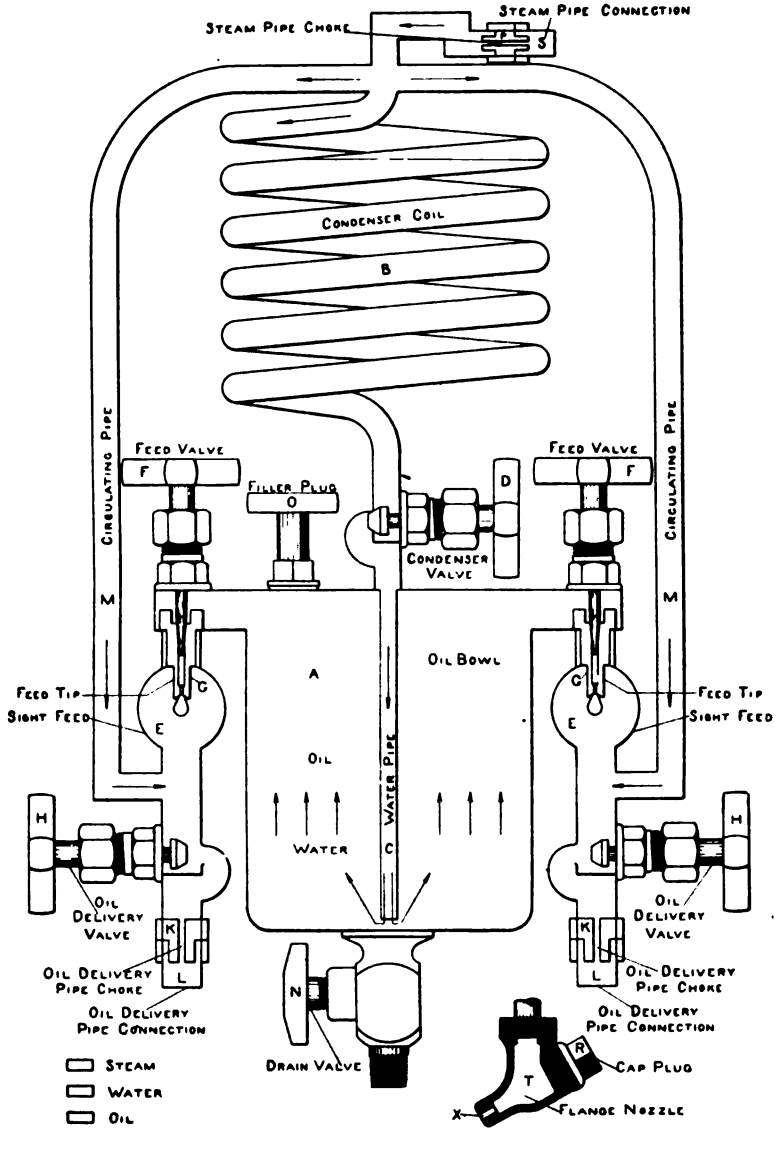


Fig. 4.— Hydrostatic Flange Oiler — Diagrammatic View.

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to the flange nozzles. The oiler is similar in general appearance and principle of operation to the sight-feed valve-chamber lubricators in general use in America and is illustrated in Figs. 3 and 4. The manufacturers recommend that the nozzles be located 15 inches above the rail, 2 inches from the flange toward the outside of the tire and close in toward the tread. (See Fig. 5.) Where two pairs of nozzles are used, each delivery pipe is branched through a "T" pipe connection. Where more than two

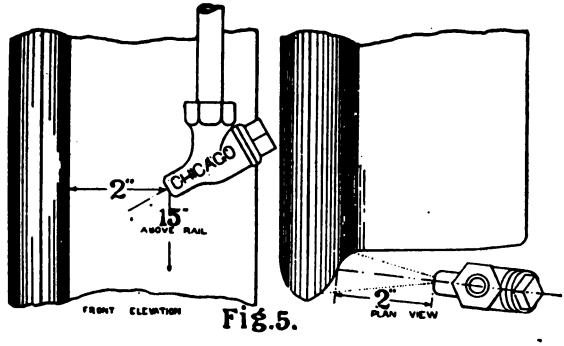


Fig.5.

APPLICATION OF FLANGE NOZZLES, HYDROSTATIC OILER.

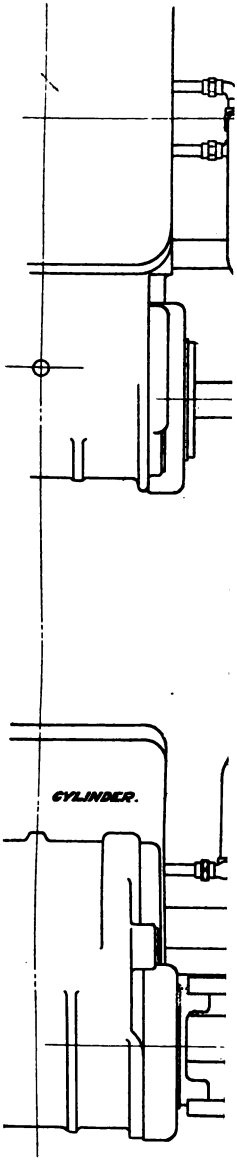
pairs are used either two two-feed oilers or one four-feed oiler should be provided. The manufacturer's practice is to apply one pair of nozzles in front of forward driving wheels on road engines; one pair in front of forward drivers and one pair back of rear drivers on switch engines; on Mallet engines in road service, one pair in front of forward drivers on both engines, and in pusher service one pair in front of forward drivers of both engines and a third pair back of rear drivers on high-pressure engine.

The Wabash Pittsburg Terminal Ry. applies nozzles to all drivers on standard type; to front and main drivers on ten-wheel type; to front and back drivers on consolidation type; to main and back drivers on six-wheel switch engines; and to front and back drivers of both engines on the Mallet type. A few consolidation engine trucks are also equipped.

The Lake Shore and Michigan Southern Ry. applies lubricator nozzles to all drivers on switch engines. The practice adopted by the Santa Fe System is to apply nozzles to the rear of forward drivers where trouble is experienced from frozen sand pipes with nozzles placed in front of the drivers.

The lubricator illustrated in Fig. 6 has been developed by the Southern Pacific Company after experiments covering the use of a number of other methods of delivering oil to the flanges. This device consists of a steam-jacketed receptacle holding about one and one-half pints of crude oil,

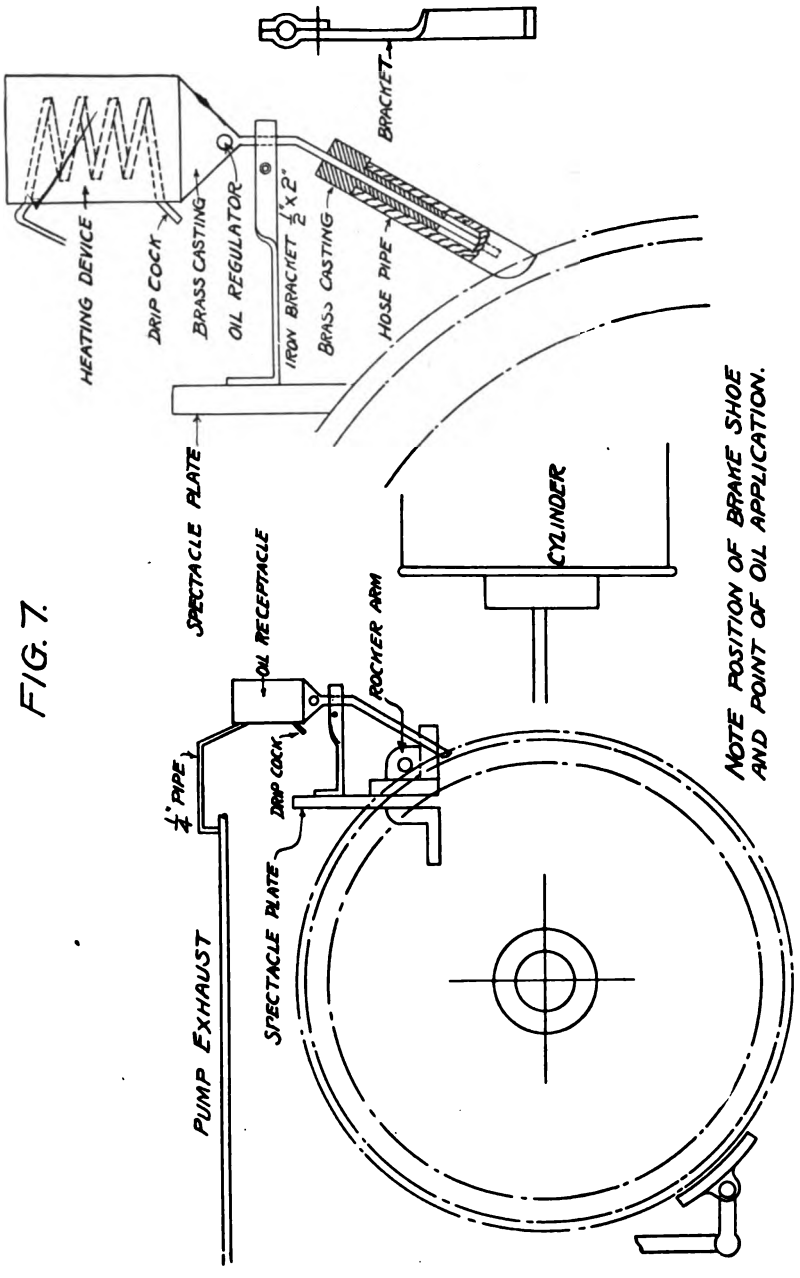
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FIG. 7.



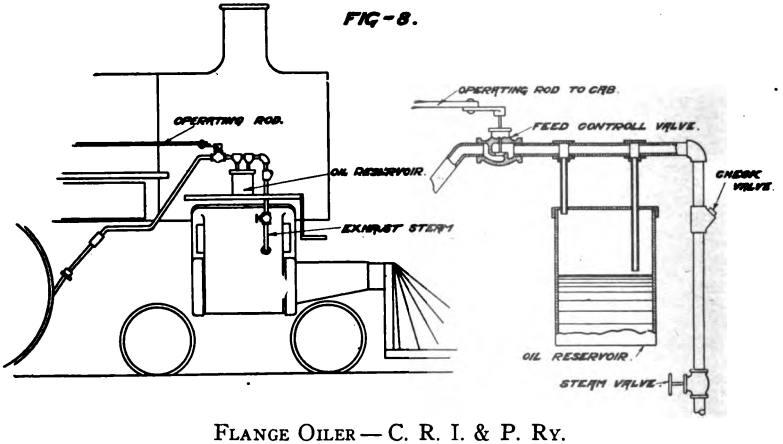
FLANGE OILER — CANADIAN PACIFIC RY.

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which is fed by gravity through a needle valve into the one-half-inch delivery pipe. A clamp bracket gripping the pipe just below the oil cup secures the oiler to the engine frame in front of the forward drivers. Loosely sliding upon the delivery pipe is a piece of one-inch pipe over the lower end of which is slipped a short section of one-inch rubber hose. The projecting end of the hose is shaped to fit the throat of the flange and acts as a shoe to distribute the oil. A weight rigidly attached to the upper end of the one-inch pipe holds the shoe against the flange at all times. The oil-cup jacket is supplied with steam from the air-pump exhaust pipe, which serves to keep the oil in a fluid state during cold weather. The drip from the jacket runs along the delivery tube tending to prevent congealing of the oil before reaching the flange.

The Canadian Pacific Railway having tried hard grease and engine oil without success is about to try crude oil in the lubricator shown in Fig. 7. This is similar to the Southern Pacific type in principle. Oil is fed through a regulating valve from the cup to the feed pipe and flange shoe, which consists of a piece of rubber hose. Steam from the air-pump exhaust pipe passing through a coil placed within the oil cup maintains the oil in a fluid state.

The Chicago, Rock Island & Pacific Ry. is using a lubricator shown in Fig. 8 on two Pacific type locomotives. The oil receptacle stands upon the running board over the right cylinder. Exhaust steam passes through

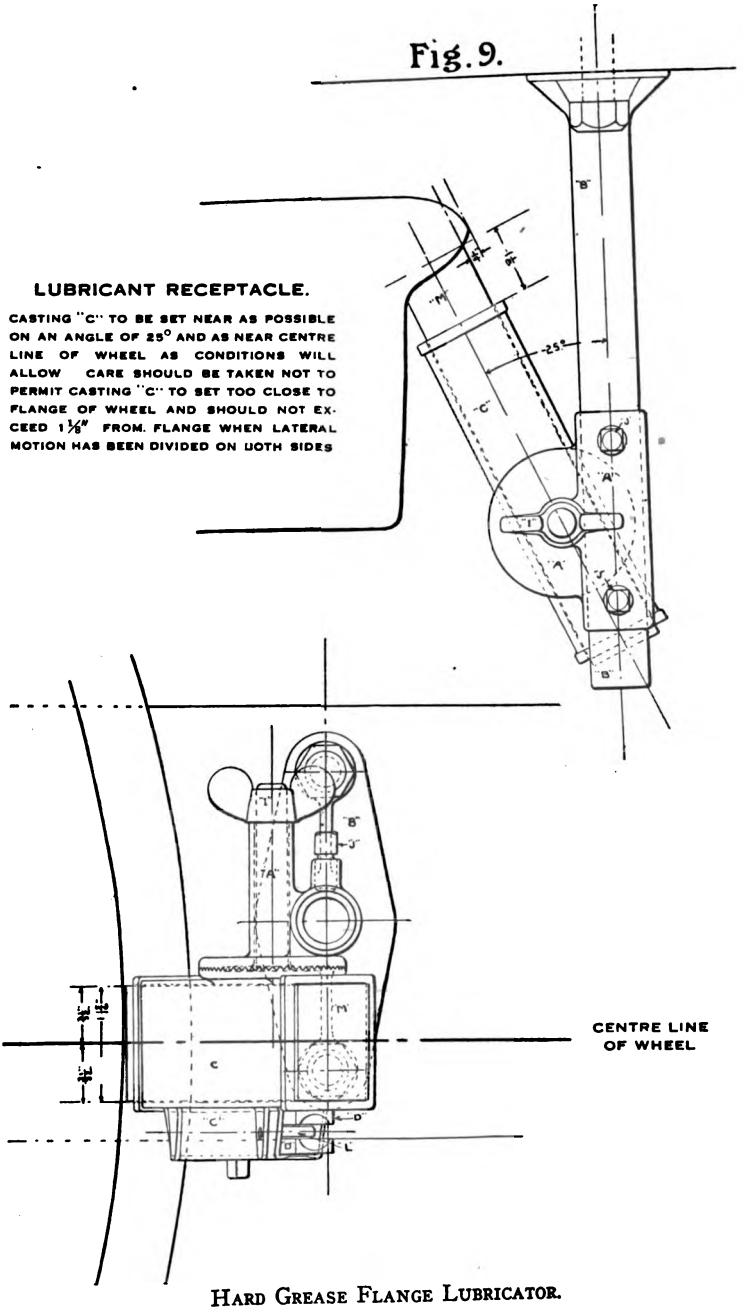


FLANGE OILER — C. R. I. & P. RY.

a pipe leading from the exhaust cavity in the cylinder casting to the oil cup. The accumulation of condensation in the oil cup lifts the lubricant into the delivery pipe, exhaust steam carrying it to the flange. The flow of oil is controlled by the engineer through a globe valve operated by a rod extending back to the cab. A check valve placed in the pipe leading

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Fig. 9.



HARD GREASE FLANGE LUBRICATOR.

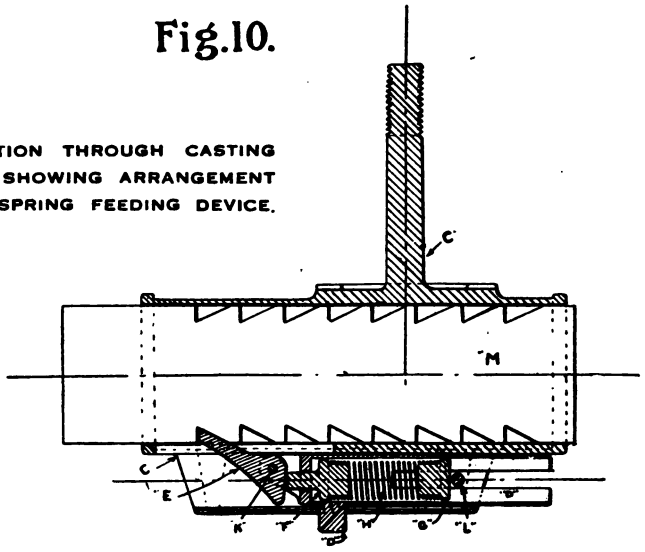
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from the cylinder exhaust cavity prevents a back flow of oil through this pipe.

There are two lubricators in use employing lubricant in solid form; the Collins and the Turnbull. The Collins is illustrated in Figs. 9, 10 and 11. A bracket attached to the frame supports the lubricator in position before the driver. The angle of the lubricator is adjustable to suit conditions imposed by the location of the bracket, on which it is laterally adjustable. The angle should be as nearly as possible twenty-five degrees from a line parallel to the axle and it should be placed on the horizontal

Fig.10.

SECTION THROUGH CASTING "C" SHOWING ARRANGEMENT OF SPRING FEEDING DEVICE.



SECTION SHOWING SPRING FEEDING DEVICE — HARD GREASE FLANGE LUBRICATOR.

center line of the wheel. The location recommended by the manufacturers is shown in Fig. 9. The lubricator itself is a tube of rectangular cross-section through which slides the lubricator block of hard grease. Below this tube is a spring-feeding device designed to keep the lubricator block pressed against the flange. Pressure from a coil spring acts through a dog engaged in one of a series of notches on the under side of the lubricator block. As the lubricant becomes worn, the spring is recompressed by means of a downward projecting trigger "D," shown in Fig. 10. At the same time the dog is moved back into engagement with the next notch in the lubricator block. This periodical readjustment is the only attention required to operate the lubricator.

The Turnbull lubricator embodies the same principle, spring pressure

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holding a cake of hard grease against the flange. The committee is informed by the manufacturer that this device is no longer marketed and a more detailed description will, therefore, be unnecessary.

Great economy in the use of lubricant is claimed for hard-grease lubricators. When the flange has become once coated there is no further deposit of lubricant until this coating is removed by contact with the rail.

The feed is automatically regulated to suit the varying needs of the flanges. On the Colorado & Southern Ry., however, it has been found that the grease used in the Turnbull lubricator absolutely loses its merit in

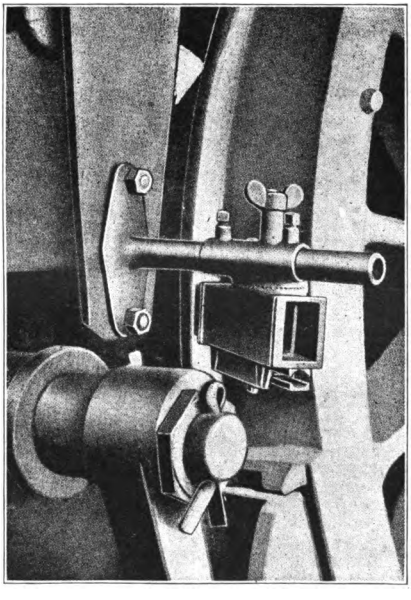


FIG. 11.— HARD GREASE LUBRICATOR IN SERVICE POSITION ON FRONT DRIVER OF LOCOMOTIVE.

either wet or cold weather and its use has been abandoned. On the Canadian Pacific, Lines West, hard-grease lubrication has been found unsatisfactory. The committee is unable to state what type of lubricator was used.

Several methods of delivering engine and car oil to the flange have been tried. The simplest is a piece of pipe or hose secured to the frame in front of the driver in such a manner as to cause the lower end to bear against the flange. The pipe or hose is filled with oil-saturated waste, which acts as a swab, more oil being supplied from time to time. This

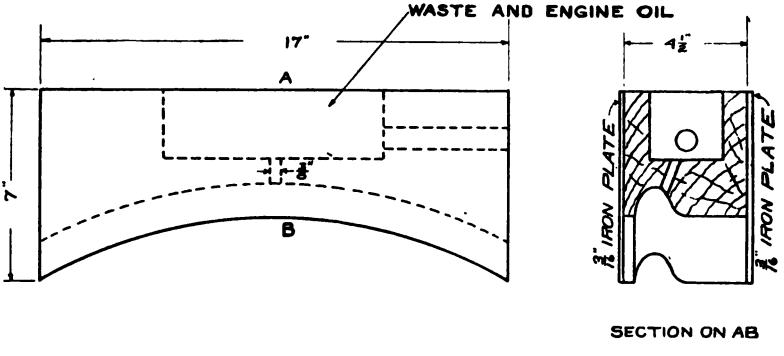
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type is sometimes varied by providing a graduated feed oil cup to supply oil to the swab. Although this simple device has proved beneficial, it has usually been abandoned for some more efficient method of lubrication. Where the waste comes in contact with the tire, if packed hard, it will glaze and cease to be effective. If loosely packed, it will be drawn out and lost.

Crude oil is being used in this manner on the Illinois Central Ry. A piece of 2-inch tube is flattened at one end and shaped to the contour of the flange. It is clamped to a hinge bracket so that the weight of the pipe itself tends to keep it in contact with the flange. The tube is packed with waste saturated with fuel oil. The shape of the opening at the flange is such that the waste will not be in contact with the tire. This device is being used to a limited extent on Pacific type engines with very little apparent benefit. It is not reliable in cold weather.

The Canadian Pacific has experimented with a siphon lubricator using engine oil, but this has proved inefficient and has been abandoned for the fuel-oil lubricator shown in Fig. 7.

Fig. 12.



SIMPLE FLANGE LUBRICATOR USING ENGINE OIL.

Another simple device has been applied to six-wheel switch engines in the Chicago yard of the Santa Fe. This is shown in detail in Fig. 12 and applied to engines in Fig. 13. It is simply a block of wood resting upon the tire and grooved to fit the flange. A waste-filled cavity contains engine oil which feeds through a ⅜-inch hole to the flange. The block is loosely anchored, as shown in Fig. 13, and is usually applied to forward and back drivers.

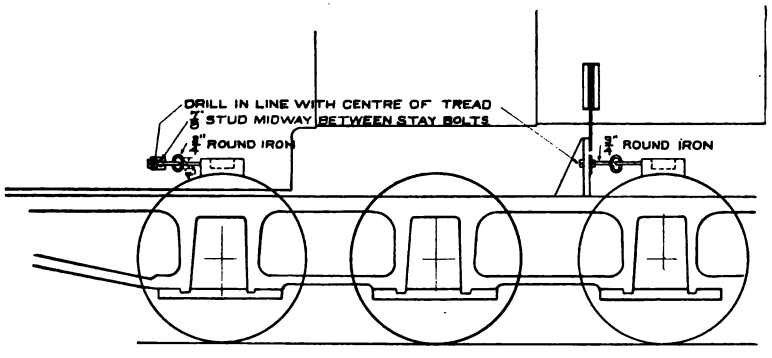
The Chicago, Rock Island & Pacific Ry. has ten Pacific and three consolidation locomotives arranged with piping to carry water from the tank to nozzles spraying against the leading drivers. This means of lubrication

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is of very limited service. The pipes run horizontally along the engine frames and cause trouble by freezing during winter weather.

The Pennsylvania Railroad has made use of exhaust steam from the air pump in the manner shown in Fig. 14, with what success we are not informed.

Fig.13.



LUBRICATOR ILLUSTRATED IN FIG. 12, APPLIED TO DRIVING WHEEL FLANGES.

Of the lubricators described, all are in very limited use except those using crude oil. Table V shows the extent of application of each lubricator named. It will be noted that every railroad is using crude oil — some exclusively.

TABLE V.

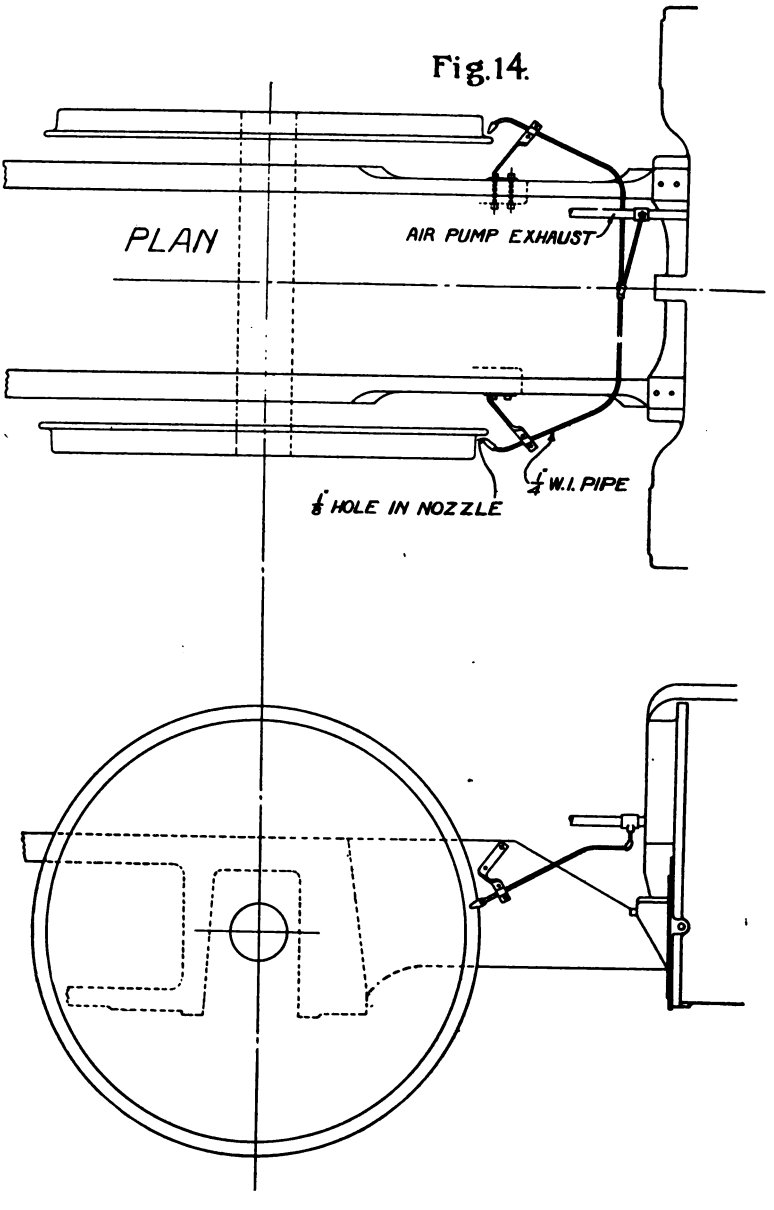
SHOWING TYPES OF LUBRICATORS AND EXTENT OF APPLICATION.

TYPES.	Roads Specifying in Use.	Remarks.
All types	21	
All types using Crude Oil	21	
Chicago	18	
Southern Pacific	2	
Rock Island	1	
Canadian Pacific	1	
Waste filled iron pipe—Crude Oil.	1	Not extensively.
Swab—Engine or Car Oil	3	Two have abandoned this type.
Siphon—Engine or Car Oil	1	Has been abandoned.
Wood Block—Engine Oil	1	
Turnbull	3	Two have abandoned this type.
Collins	2	
Hard Grease (‡)	1	Has been abandoned.
Exhaust Steam—Air Pump	1	
Water from Tank	1	
Water from Injector delivery	1	Has been abandoned.

(‡)—Type not specified.

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Fig.14.



FLANGE LUBRICATION BY MEANS OF EXHAUST STEAM FROM THE AIR PUMP.

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Flange lubrication on the Santa Fe has been developed to its present state after experiments covering the use of most of the simple devices, such as swabs of oil-saturated waste, water jets operated from the injectors and the block type shown in Figs. 12 and 13. These have all proved to be in some manner unsatisfactory. In using the simple swab difficulty was found to keep it against the flange and the waste was frequently lost. When forced against the wheel with sufficient pressure to insure constant contact the pipe was rapidly worn away, sufficient heat often being generated to ignite the waste. The water jet caused clogging of the sand pipes. Water and engine oil have both proved too light to satisfactorily resist the action of centrifugal force, being thrown away from the throat of the flange before reaching the rail. It has been found that the wood block lubricator spreads oil over the tire tread and, consequently, tends to cause slipping of the drivers.

Crude oil is now in general use for flange lubrication on the Santa Fe System. Oil from the Kansas field has not been found heavy enough to properly adhere to the flange, but that from Bakersfield, California, which is now used, has proved very satisfactory.

Experience indicates that the delivery of a proper lubricant to the flange will reduce the wear of both flange and rail. The committee's information is confined largely to the results obtained by lubrication with crude oil. California crude oil contains a high percentage of petroleum asphalt. When delivered to the rail by the driving-wheel flange, it forms a thin coating of paste on the inside of the ball of the rail which does not run or spread over the top. When all engines on a division are equipped with lubricators the rails on the outside of curves will become thus coated, and friction will be reduced on all wheels passing over the track. The resulting reduction in flange wear is noticeable on both passenger and freight car wheels, but data are available for locomotive driving wheels and tender truck wheels only. It necessarily follows that train resistance is much reduced on curves.

Reference has already been made to the losses due to flange wear in Tables III and IV. The record of Atlantic type locomotives referred to in Table III is a good illustration of the service of flange lubrication. These locomotives operating on the Atchison, Topeka & Santa Fe Railway averaged four months with a mileage of 18,600 between tire turning due to worn flanges. The division to which they were assigned includes a large amount of curved track and to increase the mileage between tire-turning flange lubricators were applied. Since their adoption, tires on the same locomotives remain in service about thirteen months, when it becomes necessary to turn them because of tread wear. During this period, the engines will average a total service of 60,400 miles. It must be added, however, that at about the time lubricators were applied, a grade revision commenced and the curvature has since been reduced on the division over which these engines were operated. But this was not completed soon

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enough to have any marked effect in the saving which was immediately apparent after applying lubricators.

The block lubricator previously described (Figs. 12 and 13) applied to six-wheel switch engines has extended the period between turning for flange wear in some cases from two months to one year.

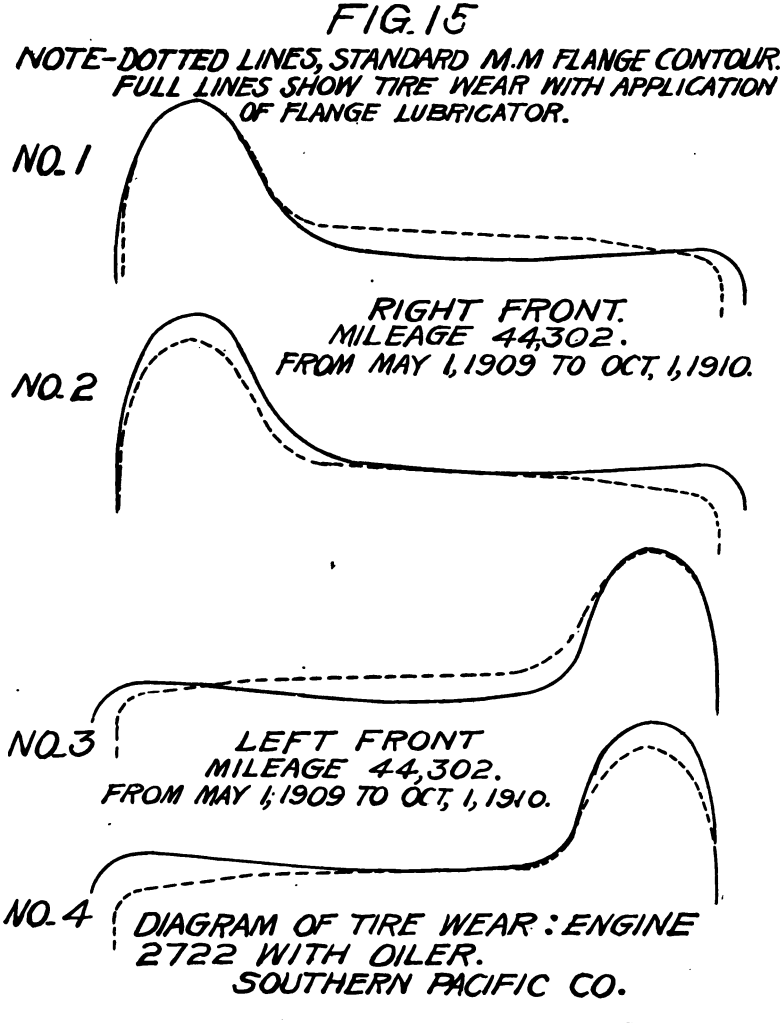


DIAGRAM OF TIRE WEAR: ENGINE 2722 WITH OILER — SOUTHERN PACIFIC CO.

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On the New Mexico Division, a 65-mile section of which has 288 curves of 6, 8 and 10 degrees, it was found impossible to keep engines of the Santa Fe type in service for more than 18,000 to 20,000 miles. After one of these locomotives had made this mileage flanges were so badly worn that it was necessary to remove all wheels and turn the tires or shift them from one pair of wheels to another. At the present time with lubricators applied they are making as high as 35,000 to 40,000 miles between shoppings with no evidence of flange cutting. On Pacific type locomotives operating through the same territory the difference is even greater. The mileage formerly obtained was about 25,000 to 30,000, which has been increased to 75,000 to 100,000 miles, with flanges still in good condition. The performance of lubricators has been closely watched in this territory. There are instances where lubrication has not entirely stopped flange wear because of the difficulty experienced in getting engineers to give the lubricators proper attention.

There are no data on the Santa Fe to show the exact increase in the life of rails on curves effected by the flange oilers. On the New Mexico Division with 100 per cent of the locomotives equipped, it has been estimated that there has been an increase of about two months in the life of rails, that previously required changing about every thirteen months. This is an increased life of 15 per cent. In territories where no figures are available, it is, however, the opinion of all officials that the flange oilers have materially decreased rail wear.

The Southern Pacific has gathered data showing the saving in tire attention effected on consolidation locomotives in mountain service, which is presented in Table VI. The average mileage per change of tires has been increased from 8,869 to 42,151, the cost of tire attention being thereby decreased 79 per cent. The miles per change of tender-truck wheels has been decreased in still greater proportion. From 3,517 before the adoption of lubrication it has been extended to 18,837, with a decrease in cost of tire attention of 81.45 per cent. Fig. 15 shows how completely flange wear has been overcome. Referring to the diagrams there presented, dotted lines show standard Master Mechanics' tire contour and full lines show contour of worn tire. In Exhibits Nos. 2 and 4 is shown the metal which must be removed to bring tires back to the standard. In no case is it necessary to remove extra metal from the tread in order to build up the flange.

The effect on wear of rails on curves has been no less marked. Where rails on 8-degree and 10-degree curves would last only about eight or ten months, conservative figures place the life since general application of flange oilers at about three years. In Figs. 16 and 17 is graphically presented the reduction in rail wear effected on two 8-degree and two 10-degree curves.

It is a fact that any device not directly necessary to the operation of the locomotive must perform its function with very noticeable results before winning the approval of the engineer. Flange lubricators on the Southern Pacific have become a necessary part of the locomotive equipment in moun-

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tain territory. When not working properly engineers complain seriously until they are repaired. Locomotives ride easier and smoother around curves without the tendency to climb the rail which is evident when flanges run without lubrication.

TABLE VI-B.

TENDER TRUCK WHEELS.

SAVING EFFECTED BY USE OF DRIVER FLANGE LUBRICATORS ON FORWARD DRIVERS OF MOUNTAIN ENGINES, SOUTHERN PACIFIC.

Total mileage of ten selected engines before application of flange lubricators, from January 1, 1909, to date of application	629,703
Number of pairs of tender truck wheels changed from January 1, 1909, to date of application of flange lubricators	148
Mileage per change of tender truck wheels	3,517
Estimated cost to change one pair of tender truck wheels	$15.55
Cost of tender truck wheel tire attention per mile run	.00442
Number of pairs of tender truck wheels changed from date of application of flange lubricators to December 31, 1908	9
Total mileage of engines from date of application of flange lubricators to December 31, 1908	169,529
Miles run per change of tender truck wheels	18,837
Percent of increase in mileage per change of tender truck wheels	435.59
Cost of tender truck wheel tire attention per mile run	.00082
Percent of decrease in cost of tire attention	81.45

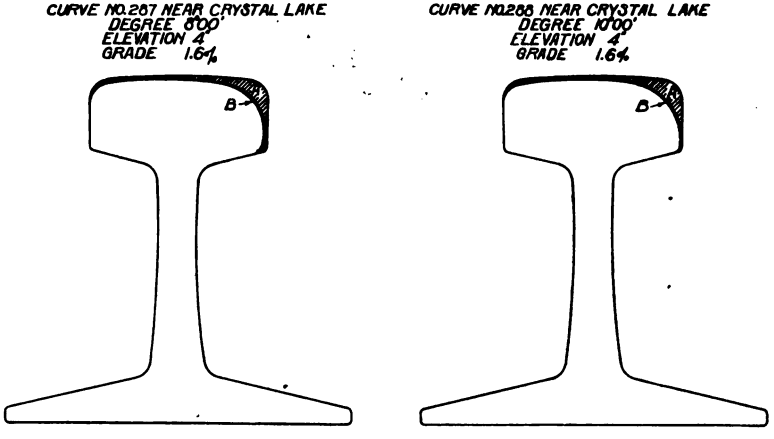
69 CONSOLIDATED ENGINES.	Average Mileage per month per engine.	Estimated Total mileage per year.	Cost per Mile Run.	Estimated Total cost of tire attention one year service.
Before application	2,491	2,062,548	$.0042	$9,116.46
After application	2,559	2,118,852	.00082	1,737.46
Amount saved by use of lubricators	.....	56,304	.....	$7,379.00

On the Wabash Pittsburg Terminal Ry. before the application of lubricators the average time between shopping for sharp flanges was eight months. A ten-wheel freight engine, working on a section having maximum curvature of 11 degrees 28 minutes, would not run three months before developing flange wear to such an extent that tires had to be turned. Since applying the lubricator this engine working on the same section of the road was out twenty months before shopping, when tires were turned for tread wear. Since the application to all locomotives there has been no occasion to turn tires for flange wear. It has stopped almost entirely on wheels to which the oil is delivered, and oiling the drivers materially decreases the wear on engine-truck wheel flanges. In some cases, oil has been applied to the trucks where wear was unusually excessive. Mallet

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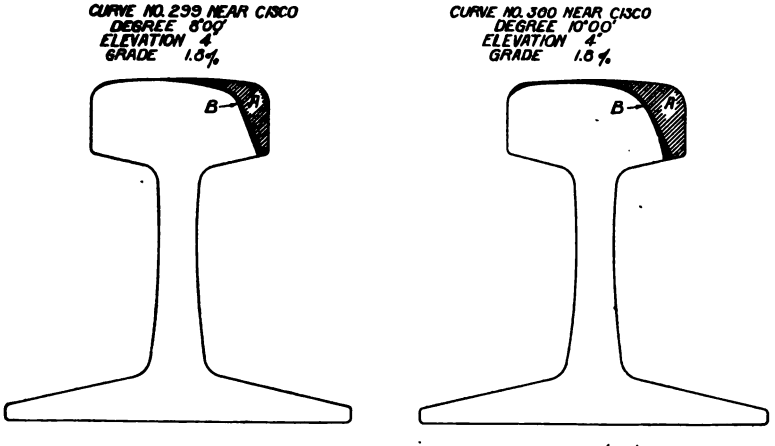
locomotives showed some signs of cutting the front flanges on the low-pressure engine. By plugging the nozzles leading to the back drivers on this engine and delivering the same amount of oil that was previously used on both pairs to the front wheels, the cutting has been reduced and

FIG. 16.



FULL SIZE DIAGRAM SHOWING WEAR ON BETHLEHEM STEEL RAIL (O.H.).
'A' INDICATES WEAR FOR 3 MONTHS BEFORE FLANGE OILERS WERE INSTALLED.
'B' INDICATES WEAR FOR 3 MONTHS AFTER FLANGE OILERS WERE INSTALLED.

FIG. 17.



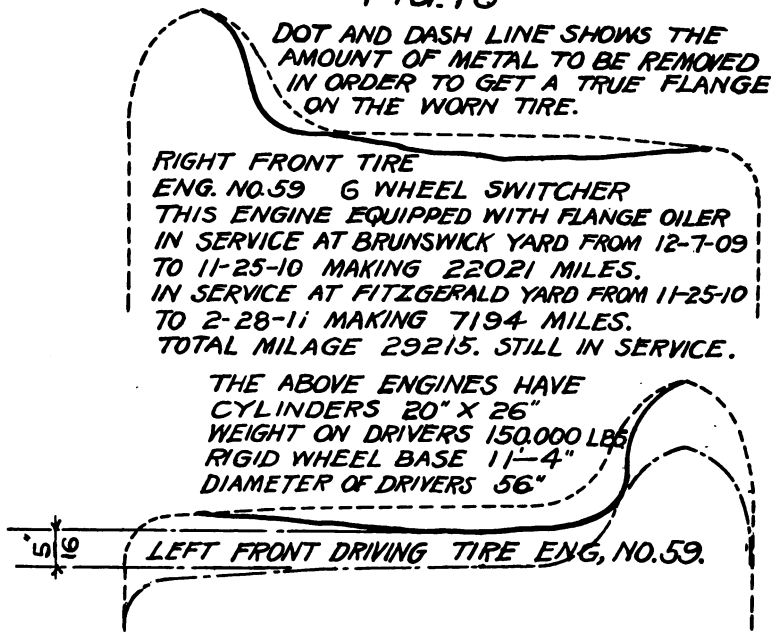
FULL SIZE DIAGRAM SHOWING WEAR ON CARNEGIE STEEL RAIL (O.H.)
'A' INDICATES WEAR FOR 3 MONTHS BEFORE FLANGE OILERS WERE INSTALLED.
'B' INDICATES WEAR FOR 3 MONTHS AFTER FLANGE OILERS WERE INSTALLED.

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it has been found that the other wheels are sufficiently oiled. In addition to the direct benefit to the locomotive, there has been a decrease in the wear of switch points and rails on curves, as well as a decrease in the number of derailments. Flange wear has also been reduced on tender truck wheels.

The Atlanta, Birmingham & Atlantic Ry. has gotten as high as 50,000 miles out of locomotives that ran only 13,000 to 15,000 miles before lubrication was adopted. The average length of service for switch engines without lubricators was three or four months at twelve hours per day. Fig. 18 shows the conditions of flanges on a switch engine that ran fourteen months, three months of this time at twenty-four hours per day, after applying the lubricator. At the time the record was taken this engine was still in service. Another individual case on this road shows forcibly the effect of lubrication. A ten-wheel locomotive, weighing 130,000 pounds on drivers, in making 18,958 miles, had cut the front flanges very badly. Owing to the rush of work it was necessary to keep the engine in service if possible. A lubricator was applied and the engine again placed in service. After making 34,495 additional miles, the flanges showed no further wear. The tires were shifted and the engine again put into service. The

FIG. 18



TRACING MADE FROM PLASTER CASTS TAKEN FROM TIRES

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TABLE VII.

Record of Wear of Flanges in Connection with Test of Chicago Flange Oilers.

N. & W. Ry.

Equipped with Flange Oilers—Engines.

Engine.	In Service.		Mileage.	Wear of Flanges.			Average Wear per 10,000 Miles.
	From	To		Max.	Min.	Avge.	
1004	6-29-09.	11-11-10	49,256...	R-1 .36″	L-1 .04″	.170″..	.034″
1005	7-17-09.	8-29-10.	43,634...	L-1 .27″	R-1 .07″	.156″..	.036″
1006	8-6-09..	8-22-10.	38,938...	L-1 .22″	R-1 .02″	.120″..	.032″
			Average of engines.....			.155″	.034″

Not Equipped with Flange Oilers—Engines.

100 0	8-4-09..	8-12-10.	36,728...	R-4 .30″	L-3 .00″	.148″..	.040″
1007	7-23-09.	8-11-10.	40,251...	R-1 .27″	L-3 .03″	.143″..	.035″
1009	9-15-09.	8-18-10.	35,628...	L-4 .11″	R-3 .02″	.066″..	.018″
			Average of Engines.....			.151″	.031″

Tank Steel Wheels behind Engines with Oilers.

1004	.....	.....	.....	R-1 .51″	L-2 .02″	.2207″.	.042″
1005	.....	.....	.....	L-3 .42″	R-3 .03″	.17″...	.039″
			Average of both.			.196″	.041″

Tank Steel Wheels behind Engines Without Oilers.

1000	.....	.....	.....	R-3 .31″	R-4 .00″	.10″...	.054″
1009	.....	.....	.....	L-3 .17″	R-4 .00″	.20″...	.028″
			Average of both			.150″	.041″

Oil.

Engine.	Used Gal..	Price, Gal.	Cost per 10,000 Miles.
1004.....	42	$0.25	$2.15
1005.....	40	.25	2.29
1006.....	48	.25	3.08

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condition of the front tires at the time the lubricator was applied and at the time tires were shifted is shown in Fig. 19. The cost of oil has been about 3 cents per 100 engine miles.

The Norfolk & Western equipped four consolidation locomotives with lubricators and compared them in service with three others of the same type. The data obtained are presented in Table VII, which shows for each engine the wheel having maximum wear, the wheel having minimum wear and the average for all wheels, which is reduced to wear per 10,000 miles for the purpose of comparison. The average wear per 10,000 miles averaged for the three locomotives without lubricators is slightly less than the same quantity shown for three engines with lubricators.

Fig. 20 shows the method used to measure the degree of flange wear, the contour being obtained by a recording device. The diagrams there shown on front tires from engine 1,009, with a mileage of 35,628 without flange oiler, indicate that flange wear was not excessive in the territory where these locomotives were working.

A service test of a yard engine was made on the Kansas City Terminal Ry. The yard where this engine worked is so located that the front and back flanges on the left side of the engine became worn to such an extent that the engine began to climb the rail after being in service about three months. It was then necessary to change tires. The engine equipped with a flange oiler was put in service with a new set of tires and remained in service under these conditions over a period of thirteen months, when it was shopped for other repairs. The flanges were still in good condition. The results obtained were made possible by the careful attention the lubricator is reported to have received from the engineer.

The foregoing instances indicate the service of flange lubrication under some of the worst conditions affecting flange wear reported to the committee. Further data are presented in Table VIII. Opposite the initials of the railroad reporting is indicated the benefit derived from flange lubrication.

M. H. Haig, Chairman,
T. W. Heintzelman,
D. J. Redding,
Committee.

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TABLE VIII.

EFFECT OF FLANGE LUBRICATION.

RAILROAD.	FLANGE WEAR STOPPED.	TIRES RUN TILL TREAD WEARS.	MILES OR TIME IN SERVICE.		No. ENGINES EQUIPPED.
			Before Lubrication.	After Lubrication.	
C. R. I. & P.	Much reduced.	Yes.	One 2–6–0	Pass. Engine.	24
			3 or 4 months.	12 months.	
B. & L. E.	Much reduced.	Yes.	14260.	23514.	2
S. P.—Sacramento Div.	Yes.	Yes.	See Table V.		. . . . .
S. P.—Salt Lake Div.	Much reduced.	*.	. . . . .	. . . . .	49
A. B. & A.	Yes.	Yes.	Road—13,000 to 15,000	50,000.	25
			Switch—3 to 4 months.	14 months.	
C. & S.—Narrow Gauge.	Yes.	Yes.	6 months.	General repairs, 12 months.	4
W. P. T.	Yes.	Yes.	3 months.	General repairs, 20 months.	24
L. S. & M. S.—Yard Engines.	Yes.	Yes.	Some instances.		15
			6 weeks.	6 months.	
H. V.	Yes.	Yes.	0–6–0	type.	2
			8,000.	34,000.	
D. & H.	Yes.	Yes.	†		20
			4 months.	8 months.	
Santa Fe—Coast Lines.	Yes.	Yes.	½ Tread wear life.	Full life.	240
Santa Fe—N. Mex. Div.	Yes.	Yes.	Pass.—25,000 to 30,000	75,000 to 100,000.	
			Frt.— 18,000 to 20,000	35,000 to 40,000.	
Santa Fe—East. Lines.	Yes.	Yes.	4–4–2	type.	120
			18,600.	60,400.	
Santa Fe—Gulf Lines.	Reduced.	No.	60,000.	75,000 to 80,000.	30
Santa Fe—So. West. Lines.	Reduced.	Not always.	10,000 to 25,000.	50,000 to 75,000.	. . . . .
				Same cases 100,000.	
T. R. R. Ass'n of St. Louis.	Reduced.	No.	About 6 months.	About 8 months.	2
M. Ry. of St. Louis.	Reduced.	Application too recent to determine.			4
E. P. & S. W.	Reduced.	Application too recent to determine.			40
P. R. R.—West Penn. Div.	No.	No.	. . . . .	. . . . .	13
N. & W.	No.	See Table VI. and Figure 19.			4
I. C.	No.	Experience limited.			Few.
C. P.	Hard Grease	and Engine Oil unsuccessful.			Few.

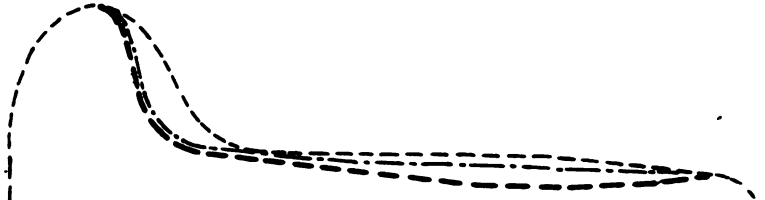
*Tires were turned for tread wear before lubricators were applied.

†Data apply to engines in pusher service. Increased life partly due to distribution of wear produced by turning the engines.

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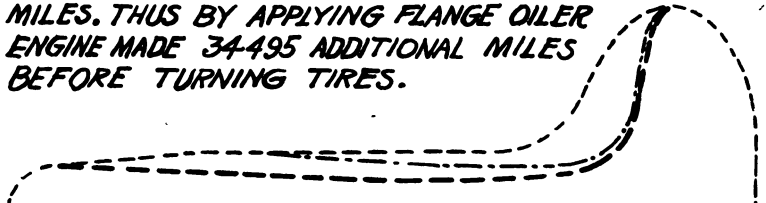
FIG. 19.

LIGHT DOTTED LINES SHOW A.B & A TRUE FLANGE
DOT & DASH LINES SHOW TIRE ON MAY 6, 10.
HEAVY DOTTED LINES SHOW TIRE ON 2-13-11.



RIGHT FRONT TIRE OF ENG. NO. 1623.

TIRES ON THIS ENGINE WERE TURNED DEC, 9. 09.
UP TO MAY 6, 10. ENGINE HAD MADE 18958 MILES
FLANGES WERE BADLY WORN AS SHOWN.
ON MAY 6, 10. FLANGE OILER WAS APPLIED AND
FROM THAT DATE UNTIL TIRES WERE REMOVED
ON 2-13-11. FLANGES SHOW PRACTICALLY NO
INCREASED WEAR. TIRES BEING REMOVED FOR TREAD WEAR.
MILAGE FROM MAY-6-10. TO 2-13-11. WAS 34495
MILES. THUS BY APPLYING FLANGE OILER
ENGINE MADE 34495 ADDITIONAL MILES
BEFORE TURNING TIRES.



LEFT FRONT TIRE OF ENG. NO. 1623

ON 2-13-11. FRONT TIRES ON ENGINE NO, 1623
WERE REMOVED, FLANGES ROUNDED UP AND
PLACED ON MAIN DRIVERS OF SAME ENGINE.
TIRES FROM MAIN DRIVING WHEELS WERE
THEN PLACED ON FRONT DRIVERS.

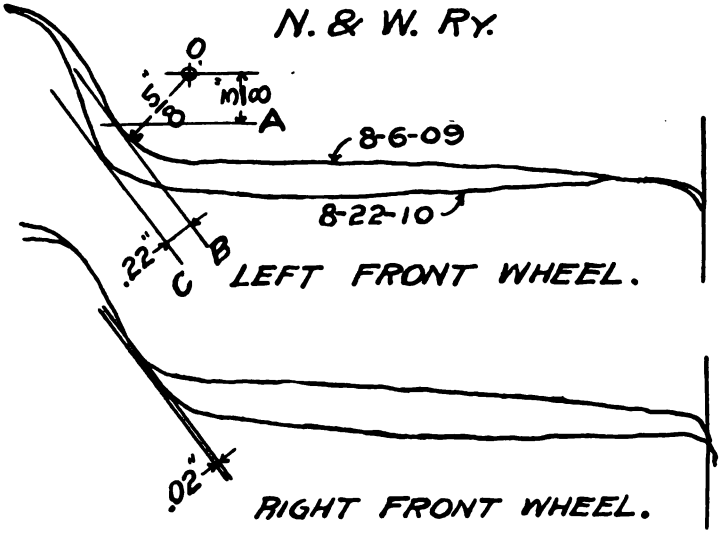
TRACING MADE FROM PLASTER CASTS TAKEN
FROM TIRES.

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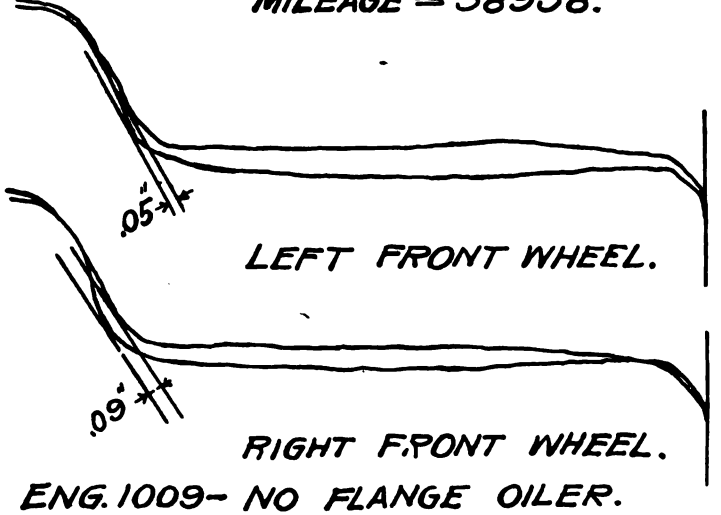
FIG. 20

REPRESENTATIVE DIAGRAMS SHOWING METHOD OF DETERMINING FLANGE WEAR.

N. & W. RY.



ENG. 1006 - CHICAGO FLANGE OILER
EQUIPPED - 8-6-09. REMOVED - 8-22-10.
MILEAGE = 38938.



ENG. 1009 - NO FLANGE OILER.
SERVICE 9-15-09. TO 8-18-10.
MILEAGE = 35628.

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THE PRESIDENT: The report will be received, and it is now open for discussion, and we shall be glad to have the benefit of the experience of anybody who has been using flange lubricators.

MR. SECHRIST: Before introducing this flange lubricator on our road we would not average over 12,000 miles before we had to change tires, and after the application of the flange lubricator we got as high as 80,000 miles. We have used the Turnbull lubricator. It is made up of two solid cakes, and we could not make a trip, say, of 137 miles before the cakes would be used up. This was caused, of course, by the friction and heat that was developed. Since we have used the Chicago lubricator and asphaltum crude oil as a base, in connection with the lubricator, we have gotten over that trouble. I believe this committee has given us the information that is necessary, for all of the railroads that have adopted the flange lubricator will verify the statements made.

MR. GAINES: I think this is one of the very important papers of this morning's session. In the past we have been very much troubled with the repeated cutting of flanges. It was not due so much to curvature of the line, either. About a year and a half ago we started in experimenting by putting on a few engines the Southern Pacific type of lubricator, and we got good results so long as we followed up the engineer, but the trouble was that he did not use it always. It was a little out of the way and not handy for him to use it. With some engineers we got excellent results. We then tried the Ohio lubricator. It seems with the use of that lubricator the engineer can watch the feeding of the oil, and it is conveniently handy for him, and he is more apt to use it. Our results with it have been very good indeed. If you take the Pacific type of engines, where we turned flanges about three times on an average we now have every reason to believe that we are going to run them right through from engine repairs to engine repairs without having to turn tires. On the Consolidation engines the results are equally favorable. We have also tried the sticky lubricators, but my experience with them is the same as that of Mr. Sechrist. They wear out too fast. Taking it all in all it seems to me that some lubricator of the form of the Ohio, with a crude oil with asphaltum as a base, is the best for the purpose.

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MR. PRATT: I would like to ask Mr. Haig if his road has used any flange lubricators on trailer wheels, and with what results? Also if they have had a large enough number of their engines equipped with flange lubricators to indicate whether lubrication on the flange of the rail would decrease the flange wear on other wheels of the engine or train? Also whether there has been any slipping of the engine on curves resulting from this flange lubrication?

MR. HANCOCK: On the Frisco System we have about 50 lubricators. We use crude oil asphaltum as a base. What saving is on the flanges of the tender wheels I am unable to say, but we are getting very good results from it on driving-wheel tire. Locomotives that cut front flanges sufficient to transfer once every three or four months, will, with the use of the lubricator, remain out until tread wear reaches the limit allowable.

At the St. Louis terminal ten heavy switch engines are equipped with flange lubricators. The engineers claim that derailments are prevented on the sharp turnouts leading on to the many industrial tracks. The road engineers in passenger service report considerably freer movement of engine on curves, account of the lubricated flanges.

MR. ANGUS SINCLAIR: I think this paper deserves the best credit that the Association can give it. I went over the paper quite carefully for the reason that I was once interested very much in the subject and I was wondering how it had been carried out. A long time ago I was running a locomotive on a very crooked road. I was responsible for the condition of the engine and had to keep it going. It quickly developed a great deal of trouble from cutting out flanges. I never had any experience to guide me as to what was to be done, but I tried swabs — a very crude way of oiling the flanges, and then I had trouble from the wheels slipping, and, consequently, I had to give that up. It did prevent the cutting of the flanges, however. Then I used tallow. I first tried blocks of tallow, and it worked fairly well. Then I mixed it with Dixon graphite and made blocks just as hard as I could get the tallow and the graphite to hold together, and I had very good results from that. With the crude oil I should imagine there should be more or less trouble with slipping. This is a sub-

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ject that deserves more consideration than it has hitherto received, and the excellent manner in which Mr. Haig has gotten up this report seems to me a splendid introduction to further study of the subject.

THE PRESIDENT: Mr. Foster, can you give us your experience on the subject?

MR. O. M. FOSTER (L. S. & M. S. Ry.): We have had very limited experience with flange lubricators, it being confined to an application to one switching engine. The results, however, have been surprisingly satisfactory. The engine works regularly on very short curves, and whereas, before the lubricator was used the driving--wheel flanges cut very rapidly and it was necessary to remove them on this account in about three months. Since the lubricator has been used the wear on the flanges is practically nothing, and the tires will probably not have to be removed at all on this account, and will last until necessary to remove them on account of being worn hollow.

THE PRESIDENT: Mr. Haig, you may now close the discussion.

MR. HAIG: I understood Mr. Pratt to ask if the flange oiler had been applied directly to trailer wheels. I will say that on the road by which I am employed flange oilers have not been applied direct to trailer wheels; I can answer his question still further by referring to what is said in the report as to the effect on wheels other than those to which the lubrication is applied directly.

There is every indication that the flange lubricator lengthens the life of the trailer wheel because of spreading oil on the ball of the rail. That effect is also observed under the tender, and to some extent on the wheels of the cars.

The effect of slipping is not serious. I will say, however, that sometimes if an engine is allowed to stand for a length of time a little oil will accumulate on the rail and that may cause slipping. Engineers have tried to overcome this by shutting off the lubricators when an engine is left standing, and that worked very well except in extremely cold weather. When the lubricator is shut off in very cold weather there is a tendency for the water to condense and the oil to freeze in the pipes. It is therefore best not to shut

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off the lubricator when an engine is left standing in exceedingly cold weather.

I think the Mechanical Department should receive some assistance in the matter of the rails and flange lubrication from the roadmaster and superintendent. I have quoted some information, received from the Chief Engineer of the Santa Fe System, and I believe the road department benefits by lubricating locomotive flanges.

THE PRESIDENT: The next subject is "Minimum Requirements for Headlights." Mr. Crawford is chairman of the committee.

MR. CRAWFORD: Mr. President and Gentlemen, your committee has gotten together considerable information on this subject from railways and also a great deal of data concerning tests on various headlights, made at Purdue University, and some tests of a number of headlights which were made at the United States Bureau of Standards. These data are rather conflicting, and the committee would like to be continued for another year, hoping at that time to submit a full report to the convention.

THE PRESIDENT: Gentlemen, you have heard the request of the chairman of the committee. What is your pleasure?

MR. BENTLEY: I move that the request be granted, and the committee continued for another year.

MR. ANGUS SINCLAIR: I second the motion.

THE PRESIDENT: All in favor of the motion will signify it by saying aye; the contrary minded, no. It is so ordered.

The next business is report of the Committee on Resolutions, etc.— Mr. G. L. Fowler.

REPORT OF COMMITTEE ON CORRESPONDENCE AND RESOLUTIONS.

MR. FOWLER: Mr. President and members of the Association. We desire to place on record the appreciation of this Association of the services of all those who have contributed to the success of this convention:

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First. The thanks of the Association to the President for his able address and to accord its appreciation of the ability with which he has presided over the meetings.

Second. To the officers of the Association for the duties they have so thoroughly performed in handling the details in connection with the necessary preparations for this convention.

Third. To the committees for the splendid reports submitted.

Fourth. To Prof. C. H. Benjamin, of Purdue University, for his valuable paper on Locomotive Performance Under Different Degrees of Superheated Steam.

Fifth. To the Committee on Arrangements for its effective service in preparing plans for the meetings.

Sixth. To the railroads for the many courtesies extended.

Seventh. To the American Railway Supply Men's Association for its magnificent exhibition of railway supplies that has become so important and essential a part of these conventions.

Eighth. To the railway press generally, and to the *Railway Age Gazette* especially, for the daily record of our meetings.

MR. GAINES: Mr. President, I move that the report of the Committee on Resolutions be received and adopted.

MR. HAIG: I second that motion.

THE PRESIDENT: All in favor of the motion will say aye; contrary minded, no. Carried. It is so ordered.

Next in order is "Unfinished Business."

THE SECRETARY: There is no unfinished business, Mr. President.

THE PRESIDENT: Then the next order will be "Election of Officers."

THE SECRETARY: The President has named the following to act as collecting tellers: Mr. MacBain and Mr. Pratt; as counting tellers, Mr. Curtis and Mr. Gaines.

I will read from the constitution the rules governing this election as follows: [Reading same.]

THE PRESIDENT: Gentlemen, you will now prepare your ballots for President.

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Have all members present who desire to do so voted? As everybody seems to have voted, I declare the ballot closed.

While the tellers are counting the vote members may prepare their ballots for Vice-President, to save time.

MR. GAINES: Mr. President, the tellers are ready to report on the vote for President.

THE PRESIDENT: Gentlemen, give your attention to the announcement of the vote for President.

MR. GAINES: Total number of ballots cast, 75; for H. T. Bentley, 71; for D. F. Crawford, 3; scattering, 1.

E. W. PRATT: I move that the election of Mr. Bentley be declared unanimous.

ANGUS SINCLAIR: I second the motion.

THE PRESIDENT: All in favor of the motion will signify it by saying aye; contrary minded, no. Carried. It is so ordered, and I direct the Secretary to cast the unanimous ballot of the Association for the election of Mr. Bentley as President of the Association for the ensuing year.

THE SECRETARY: Mr. President, I have cast the ballot of the Association as directed for Mr. H. T. Bentley.

MR. GAINES: The tellers are ready to announce the votes cast for First Vice-President.

Total number of ballots cast, 65; for D. F. Crawford, 56; for T. Rumney, 2; scattering, 7.

MR. JOHNSON: Mr. President, I move that the Secretary cast the ballot of the Association for the unanimous election of Mr. Crawford.

T. RUMNEY: I second that motion.

THE PRESIDENT: All in favor of the motion will signify it by saying aye; contrary minded, no. Carried.

It is so ordered. The Secretary will cast the ballot.

THE SECRETARY: Mr. President, I have cast the ballot.

THE PRESIDENT: I declare B. F. Crawford duly elected First Vice-President of the Association. [Applause.]

Gentlemen, now prepare your ballots for Second Vice-President.

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MR. GAINES: Mr. President, the tellers report total number of ballots cast for Second Vice-President, 73. For T. Rumney, 70; scattering, 3.

MR. ANGUS SINCLAIR: I move that the Secretary cast the unanimous ballot of the Association for the election of Mr. Rumney.

MR. CURTIS: I second the motion.

THE PRESIDENT: All in favor of the motion will signify it by saying aye; contrary minded, no. Carried. It is so ordered.

THE SECRETARY: Mr. President I have cast the ballot as directed for Mr. T. Rumney as Second Vice-President of the Association.

THE PRESIDENT: I declare T. Rumney Second Vice-President of the Association. Gentlemen, now prepare your ballots for Third Vice-President.

MR. GAINES: Mr. President, the total number of ballots cast for Third Vice-President, 81; for D. R. MacBain, 55; for C. A. Seley, 16; scattering, 10.

MR. SELEY: I move that the Secretary cast the unanimous ballot of the Association for the election of Mr. MacBain.

MR. PRATT: I second the motion.

THE PRESIDENT: All in favor of the motion will signify the same by saying aye; contrary minded, no. Carried. It is so ordered.

THE SECRETARY: Mr. President, I have cast the ballot of the Association as directed for Mr. MacBain for Third Vice-President.

THE PRESIDENT: I declare D. R. MacBain duly elected Third Vice-President of the Association.

Members will now prepare their ballots for Treasurer.

MR. GAINES: Mr. President, the tellers report that the total number of ballots cast for Treasurer is 64. For Angus Sinclair, 55; for E. W. Pratt, 7; scattering, 2.

MR. PRATT: I move that the Secretary cast the unanimous ballot of the Association for Mr. Sinclair.

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MR. WILDIN: I second the motion.

THE PRESIDENT: All in favor of the motion will signify the same by saying aye; opposed, no. Carried. It is so ordered.

THE SECRETARY: Mr. President, the ballot is cast as directed.

THE PRESIDENT: I declare Dr. Angus Sinclair duly elected Treasurer of the Association.

Gentlemen, now prepare your ballots for three members of the Executive Committee. The Secretary will read the names of the Executive Committee.

THE SECRETARY: The terms of Messrs. Seley, Walsh and MacBain expire in 1911, and the terms of Messrs. Curtis, Wildin and Gaines expire in 1912. Mr. MacBain has already been elected Vice-President.

THE PRESIDENT: Gentlemen, prepare your ballots, and the three men receiving the highest number of votes will be considered elected.

THE PRESIDENT: We will listen to the report of the tellers on members of the Executive Committee to serve until June, 1913.

MR. GAINE: The following ballots have been cast: C. A. Seley, 49; E. W. Pratt, 24; J. F. Walsh, 21; J. F. DeVoy, 14; S. T. Park, 14, and C. E. Fuller, 10. The balance of the votes scattering.

THE PRESIDENT: Gentlemen, you have heard the report of the tellers. A motion will be in order to instruct the Secretary to cast a ballot for the three members receiving the highest vote.

MR. MACBAIN: I move that the Secretary be authorized to cast a ballot for Messrs. Seley, Pratt and Walsh for members of the Executive Committee.

THE SECRETARY: Mr. President, I have cast the ballot as directed by the Association.

THE PRESIDENT: This finishes the business of the meeting, and it becomes my duty to turn over to my successor the gavel, but before doing so I wish to express to the officers and individual members of this Association my appreciation of their assistance and work during the forty-fourth annual convention of this Association.

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I feel that you have ably supported me and have rendered assistance in every way possible, and I hope and feel that the same will be extended to my successor. I have no hesitancy in saying that your choice of a President is an unusually good one, and that Mr. Bentley will conduct the work of this Association with credit to himself and to the members. Mr. Bentley.

PRESIDENT-ELECT BENTLEY: Members of the American Railway Master Mechanics' Association, I wish to thank you all for the great honor you have conferred on me to-day. It is my sincere wish and hope that I may be able to carry on the work of the Association in a manner that will bring further credit to it and sustain the traditions of the past. When I consider the men who have held this position it makes me realize that I have a very big job ahead of me, and I ask that you will give me the same splendid support that you have given my predecessors in the past. Again, I thank you, gentlemen.

MR. CRAWFORD: The members and the officers of this Association as well as the railways represented owe a debt of gratitude to Mr. Fuller, our retiring President. His interest in the work of the Association is probably best evidenced by the many long journeys taken by him to Washington to attend the frequent meetings of the Safety Appliance and Boiler Inspection Committees, where his work and assistance have been particularly valuable.

I am sure that you will all agree with me that Mr. Fuller, during his term as President, has rendered splendid service to the Master Mechanics' Association, and in the advancement of the mechanical science and arts. It is, therefore, with great pleasure that I move that we all rise to indicate to him our esteem and hearty thanks. [Applause.]

EX-PRESIDENT FULLER: Mr. President and Members, I greatly appreciate your action.

PRESIDENT BENTLEY: Mr. Scott H. Blewett is present and has a few words to say.

MR. SCOTT H. BLEWETT: Mr. Fuller, Mr. President and Members of the Master Mechanics' Association: The books of rare printers, the Elzevirs and the Aldines have as a final state-

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ment: This volume was printed such and such a year by such and such a press. This was not done in order that the information might be given to the makers of these books, but that coming generations might know that the volume was genuine, not spurious.

Mr. Fuller, the work of your official life with the Master Mechanics' Association is nearly printed. Your associate members and yourself have written for the printer what is your record. It is not necessary that either they or you should have the evidence that this work has been genuine, that it is not spurious, that they are not ashamed and you are not ashamed, of what you have done, but I have been delegated the press man to put this official stamp upon the work and to ask you to recognize that they have appreciated what you have done. [Mr. Blewett handed Mr. Fuller the gold badge presented to the Ex-Presidents of the Association.]

MR. FULLER: Mr. Blewett and Friends: To say that I appreciate the honor of being President of the Association that has been my good fortune, and these kind words do not fully express my feelings, and I will not attempt to say anything more other than I thank you most sincerely.

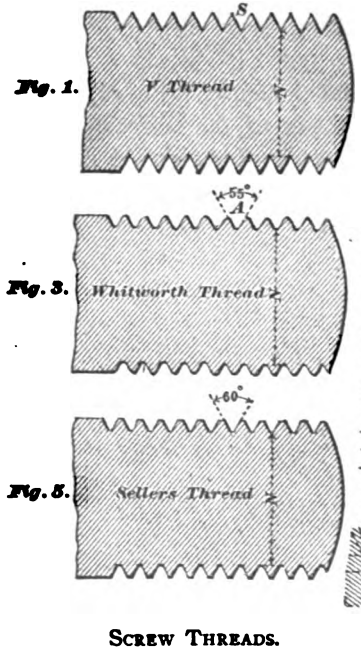
The meeting then adjourned.

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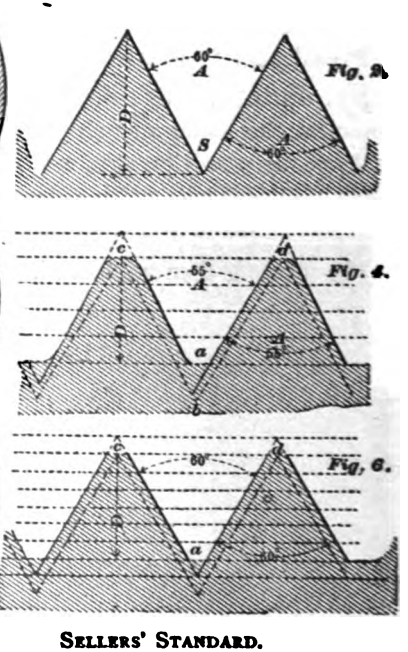
STANDARDS ADOPTED BY THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

SCREW THREADS, BOLT HEADS AND NUTS.

At the convention of 1870 the report of a committee recommending the United States Standard Screw Thread was adopted. The forms and dimensions of the threads are shown below:



SCREW THREADS.



SELLERS' STANDARD.

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Mr. Sellers, who proposed this system of screw threads, described it in an essay read before the Franklin Institute of Philadelphia, April 21, 1864, as follows:

"The proportions for the proposed thread and its comparative relation to the sharp and rounded threads, will be readily understood from the accompanying diagram in which Figs. 1 and 2 — the latter on an exaggerated scale — represent a sharp thread, Figs. 3 and 4 a rounded top and bottom to the English proportion, and Figs. 5 and 6 the flat top and bottom, all of the same pitch. The angle of the proposed thread is fixed at sixty degrees, the same as the sharp thread, it being more readily obtained than fifty-five degrees; and more in accordance with the general practice in this country. Divide the pitch, or, which is the same thing, the side of the thread into eight equal parts, take off one part from the top and fill in one part in the bottom of the thread, then the flat top and bottom will equal one-eighth of the pitch; the wearing surface will be three-quarters of the pitch, and the diameter of screw at bottom of the thread will be expressed by the formula:

$$\textit{Diameter} - \frac{1.299}{\textit{number of threads per inch.}}$$

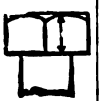
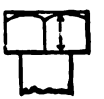
At the convention of 1892 the Association adopted as standard the United States standard sizes of nuts and bolt heads.

At the convention of 1903 the arrangement of these standards was made to conform to the arrangement as adopted by the Master Car Builders' Association.

The accompanying tables are reprinted from Mr. Sellers' essay. They give the proportions of his standard screw threads, nuts and bolt heads.

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PROPORTIONS FOR UNITED STATES STANDARD SCREW-THREADS, NUTS AND BOLTS.

Screw-Threads.				Hexagon Nuts.				Hexagon Bolt-Heads.			
Diameter of screw.	Threads per inch.	Diameter at root of thread.	Width of flat.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.
											
¼	20	.185	.0062								
5/16	18	.240	.0074								
⅜	16	.294	.0078								
7/16	14	.344	.0089								
½	13	.400	.0096								
9/16	12	.454	.0104								
⅝	11	.507	.0113	1 1/16	1			1 1/16	1		
¾	10	.620	.0125	1 1/4	1 1/16			1 1/4	1 1/16		
7/8	9	.731	.0138	1 7/16	1 1/8			1 7/16	1 1/8		
1	8	.837	.0156	1 5/8	1 5/16	1		1 5/8	1 5/16		
1⅛	7	.940	.0178	1 13/16	1 7/16	1 1/8	1 1/16	1 13/16	1 7/16		1 1/16
1¼	7	1.065	.0178	2	1 13/16	1 1/4	1 1/16	2	1 13/16	1	1 1/16
1⅜	6	1.160	.0208	2 3/16	2 1/16	1 3/8	1 1/16	2 3/16	2 1/16	1 3/16	1 1/16
1½	6	1.284	.0208	2 3/8	2 5/16	1 1/2	1 1/16	2 3/8	2 5/16	1 5/16	1 1/16
1⅝	5½	1.389	.0227	2 5/16	2 1/16	1 5/8	1 1/16	2 5/16	2 1/16	1 3/16	1 1/16
1¾	5	1.491	.0250	2 3/4	2 1/16	1 3/4	1 1/16	2 3/4	2 1/16	1 1/8	1 1/16
1⅞	5	1.616	.0250	2 15/16	2 1/16	1 7/8	1 1/16	2 15/16	2 1/16	1 15/16	1 1/16
2	4½	1.712	.0277	3 1/8	3 1/16	2	1 1/16	3 1/8	3 1/16	1 15/16	1 1/16
2¼	4½	1.962	.0277	3 5/8	3 1/16	2 1/4	2 1/16	3 5/8	3 1/16	1 15/16	2 1/16
2½	4	2.176	.0312	3 7/8	3 1/16	2 1/2	2 1/16	3 7/8	3 1/16	1 15/16	2 1/16
2¾	4	2.426	.0312	4 1/8	4 1/16	2 3/4	2 1/16	4 1/8	4 1/16	2 1/16	2 1/16
3	3½	2.629	.0357	4 5/8	4 1/16	3	2 1/16	4 5/8	4 1/16	2 1/16	2 1/16
3¼	3¼	2.879	.0357	5	4 1/16	3 1/4	3 1/16	5	4 1/16	2 1/16	3 1/16
3½	3½	3.100	.0384								

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PROPORTIONS FOR SELLERS' STANDARD NUTS AND BOLTS.



Rough Nut = one and one-half diameter of bolt + $\frac{1}{8}$.



Finished Nut = one and one-half diameter of bolt + $\frac{1}{16}$.



Rough Nut = diameter of bolt.



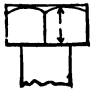
Finished Nut = diameter of bolt—$\frac{1}{16}$.



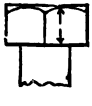
Rough Head = one and one-half diameter of bolt + $\frac{1}{8}$.



Finished Head = one and one-half diameter of bolt + $\frac{1}{16}$.



Rough Head = three-quarter times diameter of bolt + 1-16.



Finished Head = diameter of bolt—$\frac{1}{16}$.

SQUARE BOLT HEADS.

In 1899 the following dimensions for square bolt heads were adopted as standard:

The side of the head shall be one and one-half times the diameter of the bolt, and the thickness of the head shall be one-half the side of the head.

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CASTLE NUTS, COTTER PINS AND LOCATION OF COTTER-PIN HOLES IN PROJECTING BOLT ENDS.

At the convention of 1909 a series of dimensions for castle nuts, also cotter pins and bolt ends with cotter-pin location, were submitted by a committee, and on reference to letter ballot were adopted as standard. They are shown on Plate 4-A herewith, and cover the following:

1. A series of castle nuts having U. S. standard threads.
2. A series of thin castle nuts having U. S. standard threads.
3. A series of special thin castle nuts having outward proportions the same as thin castle nuts, but having a special number of threads.
4. Rough nuts with diameters across the flats as shown. These dimensions correspond with U. S. standard dimensions for hexagon nuts. Finish of flats to be obtained by grinding and buffing, or by milling, the same practice as obtains in the case of U. S. standard nuts.
5. Finished nuts to have facing washer on bottom with dimensions as shown; rough nuts to have bottom corner slightly chamfered.
6. A series of standard cotter pins.
7. A series of Player cotter pins.
8. A series of taper pins.
9. Projecting bolt ends with cotter-pin hole location.

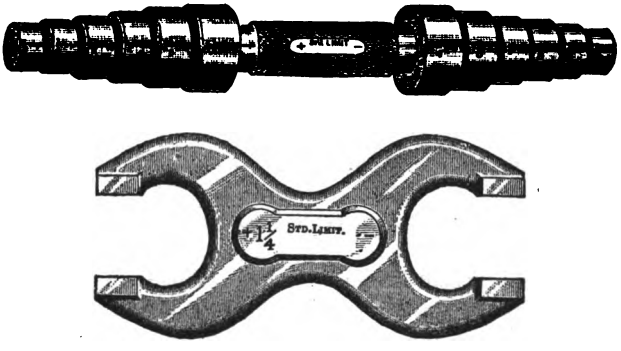
LIMIT GAUGES FOR ROUND IRON.

At the convention of 1884 the Pratt & Whitney limit gauges for round iron, shown below, were adopted as standard. (See page 168, report 1884.) Reaffirmed 1891 (see pages 160, 161, report 1891).

Nominal Diameter. Of Iron. Inches.	Large Size, End. Inches.	Small Size, End. Inches.	Total Variation. Inches.
1/4	.2550	.2450	.010
5/16	.3180	.3070	.011
3/8	.3810	.3690	.012
7/16	.4440	.4310	.013
1/2	.5070	.4930	.014
9/16	.5700	.5550	.015
5/8	.6330	.6170	.016
3/4	.7585	.7415	.017
7/8	.8840	.8660	.018
1	1.0095	.9905	.019
1 1/8	1.1350	1.1150	.020
1 1/4	1.2605	1.2395	.021
1 3/8	1.3860	1.3640	.022
1 1/2	1.5115	1.4885	.023
1 5/8	1.6370	1.6130	.024
1 3/4	1.7625	1.7375	.025
1 7/8	1.8880	1.8620	.026

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Round iron 2 inches in diameter and over should be rolled to the nominal diameter.



DISTANCE BETWEEN BACKS OF FLANGES OF STEEL-TIRED ENGINE TRUCK, DRIVER OR TENDER WHEELS.

At the convention of 1884 a motion prevailed that the standard distance between the backs of tires for tender locomotive truck and driving wheels be not less than 4 feet 5⅛ inches, nor more than 4 feet 5½ inches. (See page 26, report 1884.) Modified in 1903. See report of Committee on Revision of Standards.

In 1908 the above standard was made applicable to steel-tired engine truck, driver or tender wheels. For gauges for cast-iron wheels see Sheet M. M. 14.

GAUGES FOR CAST IRON WHEELS.

In 1908 a wheel-defect gauge and maximum flange-thickness gauge, also method of gauging, were adopted as standard, to be used when cast-iron wheels are applied to engine and tender. See Sheet M. M. 14. Modified 1909.

SECTION OF TIRE.

At the convention of 1893 the forms of tires shown on Plate I were adopted as standard. Railroad companies ordering tires will save time by specifying these forms.

In 1908 the section of tire was modified, as shown on Sheet M. M. 1.

DRIVING WHEEL CENTERS AND SIZES OF TIRES.

At the convention of 1886 the report of a committee was adopted which recommended driving-wheel centers to be made 38, 44, 50, 56, 62 or 66 inches diameter.

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In 1893 the following sizes were added to the standards: 70, 74, 78, 82, 86 and 90 inches.

In 1907, as a result of letter ballot, 72 inches was adopted as a standard size.

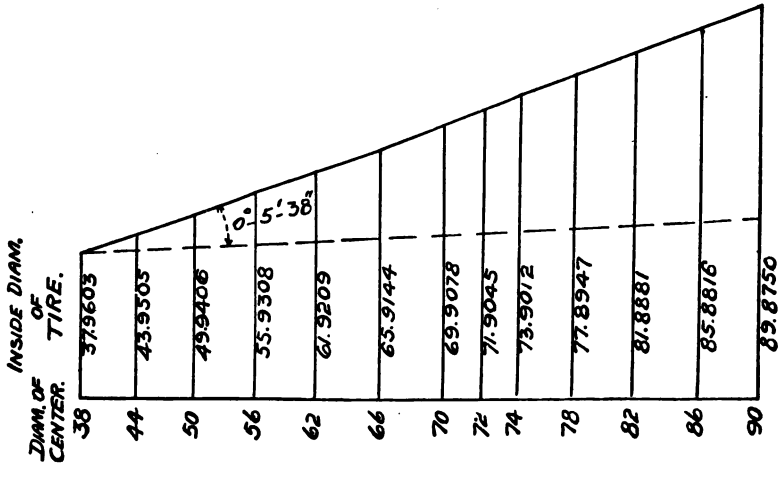
SHRINKAGE ALLOWANCES FOR TIRES.

In 1907, as a result of letter ballot, the following shrinkage allowances were adopted as standard:

For cast-iron and cast-steel centers less than 66 inches in diameter, 1-80 inch per foot in diameter.

For cast-iron and cast-steel centers 66 inches and over in diameter, 1-60 inch per foot in diameter.

In 1908 the dimensions shown in diagram below were adopted as standard, allowing 1-80 inch per foot in diameter of 38-inch centers, and 1-60 inch per foot in diameter of 90-inch centers.



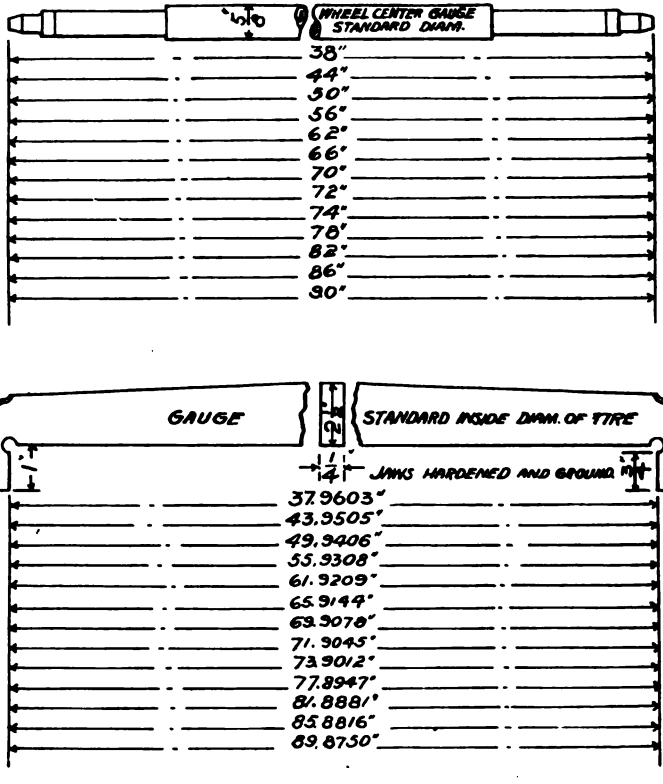
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STANDARD MASTER GAUGES FOR TURNING WHEEL CENTERS AND BORING TIRES.

At the Twentieth Annual Convention the recommendations of a committee were adopted, making tire gauges manufactured by Messrs. Pratt & Whitney, Hartford, Connecticut, standards of the Association.

In 1908 the illustrations of the gauges were made to include the dimensions for all the standard wheel centers and tires.

STANDARD MASTER GAUGES FOR TURNING WHEEL CENTERS & BORING TIRES



SPOKES.

In 1907, as a result of letter ballot, the following standards were adopted:

In order to properly support the rim and resist the tire shrinkage, spokes should be placed from 12 to 13 inches apart from center to center, measured on the outer circumference of the wheel center.

Spokes at crank hub should not be located at center line of wheel, but on either side, so as not to bring a short spoke directly in line with crank-pin hub. Section of spokes at large end to have an area of from

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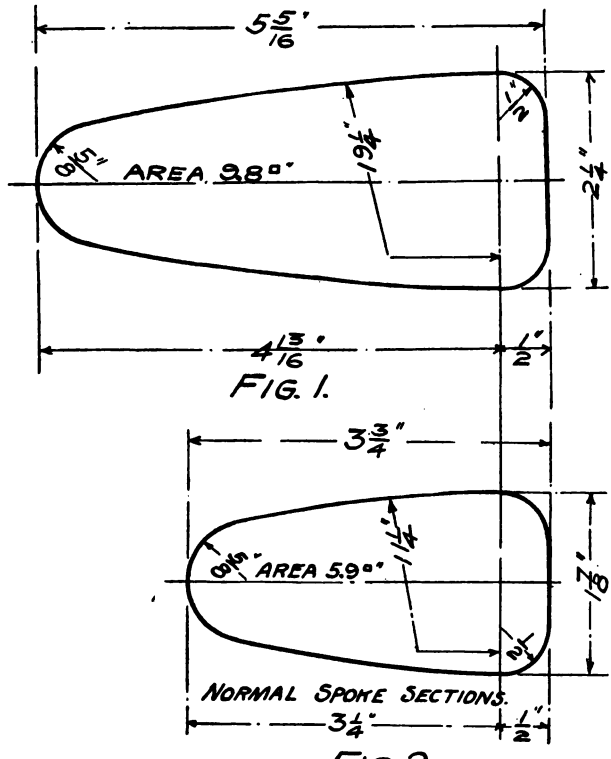


FIG. 2.

9 to 10 square inches, with form as shown in Fig. 1. Section of spoke at small end to have an area of from 5¾ to 6 square inches, with form as shown in Fig. 2. The sections shown herewith are taken at the base of the fillets uniting the spoke to the hub and rim.

DRIVING-WHEEL CENTERS.

In 1907 the following standards were adopted by letter ballot:

Cast-steel driving-wheel centers should preferably be uncut and shrinkage slots omitted; if cut, slots should be machined out and closed with solid cast-iron liners driven in. No lead or white metal should be used.

For wheel centers 60 inches and over, when the permissible total weight of the locomotive will allow, the rims should preferably be cast solid without cores, so as to obtain the maximum section and have full bearing of tires; the section in square inches should be approximately .45 of the sectional area of the tire when new.

The section of rim for wheel centers without retaining rings shall be of the form shown below:

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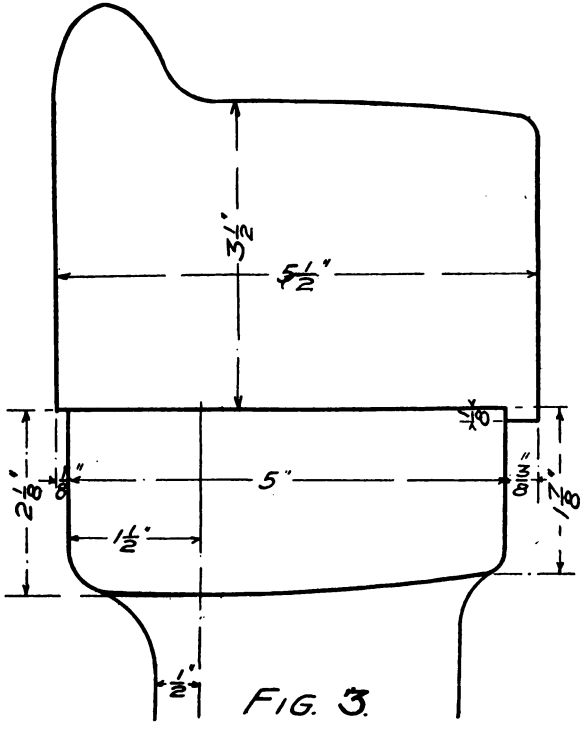


FIG. 3.

The standard distance between hubs shall be 55 inches.

SPECIFICATION FOR BOILER AND FIRE-BOX STEEL.

MADE BY THE OPEN HEARTH PROCESS.

Adopted in 1894. Revised 1904.

1. SPECIAL REQUIREMENTS FOR SHELL SHEETS.

This grade of steel is known to the trade as flange or boiler steel The desired tensile strength is 60,000 pounds per square inch, with minimum and maximum limits 55,000 and 65,000 pounds. The elongation in eight inches shall not be less than twenty-five per cent for sheets three-quarters of an inch thick or under. For thicker sheets, deduct one per cent from specified elongation for each one-eighth inch additional thickness.

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2. CHEMICAL REQUIREMENTS FOR SHELL SHEETS.

	Per cent.
Phosphorus shall not exceed (acid)	0.06
Phosphorus shall not exceed (basic)	0.04
Sulphur shall not exceed	0.05
Manganese	0.30 to 0.60

3. SPECIAL REQUIREMENTS FOR FIRE-BOX STEEL.

The desired tensile strength is 57,000 pounds per square inch, with minimum and maximum limits 52,000 and 62,000 pounds. The elongation in eight inches shall not be less than twenty-six per cent.

4. CHEMICAL REQUIREMENTS FOR FIRE-BOX SHEETS.

	Per cent.
Carbon	0.15 to 0.25
Phosphorus shall not exceed (acid)	0.04
Phosphorus shall not exceed (basic)	0.03
Sulphur shall not exceed	0.04
Manganese	0.30 to 0.50

GENERAL REQUIREMENTS.

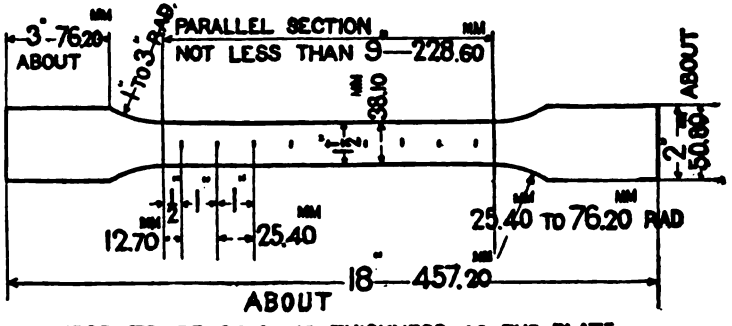
5. BENDING TESTS.

Test specimens for this purpose shall be 1½ inches wide, and for material ¾ inch or less in thickness shall be of the same thickness as that of the finished sheet. For sheets more than ¾ inch thick, the bending-test specimen may be ½ inch thick. The sheared edges of bending-test specimens may be milled or planed. The cold bending test shall be made on the material in the condition in which it is to be used. The specimen for quench bending test shall be heated to a light cherry red, as seen in the dark, and quenched in water having a temperature between 80° and 90° F. Boiler steel and fire-box steel, before and after quenching, shall bend cold 180° flat on itself without fracture on the outside of the bent portion. The bending test may be made by pressure or by blows. One cold bending specimen and one quenched bending specimen will be furnished from each plate as it is rolled. The homogeneity tests for fire-box steel shall be made on one of the broken tensile test specimens.

6. SPECIMENS FOR TENSILE TEST.

Two tensile test specimens will be furnished from each plate as it is rolled. The standard test specimen of 8-inch gauged length shall be used for the tensile test. The standard shape of the test specimens shall be as shown by the following sketch:

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PIECE TO BE OF SAME THICKNESS AS THE PLATE.

7. HOMOGENEITY TEST.

The homogeneity test for fire-box steel is made as follows: A portion of the broken tensile test specimen is either nicked with a chisel or grooved on a machine, transversely about a sixteenth of an inch deep, in three places about two inches apart. The first groove should be made on one side, two inches from the square end of the specimen; the second, two inches from it on the opposite side, and the third, two inches from the last and on the opposite side from it. The test specimen is then put in a vise, with the first groove about a quarter of an inch above the jaws, care being taken to hold it firmly. The projecting end of the test specimen is then broken off by means of a hammer, a number of light blows being used, and the bending being away from the groove. The specimen is broken at the other two grooves in the same way. The object of this treatment is to open and render visible to the eye any seams due to failure to weld up, or to foreign interposed matter, or cavities due to gas bubbles in the ingot. After rupture, one side of each fracture is examined, a pocket lens being used if necessary, and the length of the seams and cavities is determined. The broken specimen shall not show any single seam or cavity more than ¼ inch long in either of the three fractures.

8. VARIATION IN WEIGHT.

The variation in cross section or weight of more than two and one-half per cent from that specified will be sufficient cause for rejection, except in the case of sheared plates, which will be covered by the following permissible variations:

Plates 12½ pounds per square foot or heavier, up to 100 inches wide, when ordered to weight, shall not average more than 2½ per cent variation above or 2½ per cent below the theoretical weight. When 100 inches wide and over five per cent above or five per cent below the theoretical weight.

Plates under 12½ pounds per square foot, when ordered to weight, shall not average a greater variation than the following:

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Up to 75 inches wide, 2½ per cent above or 2½ per cent below the theoretical weight. Seventy-five inches wide up to 100 inches wide, five per cent above or three per cent below the theoretical weight. When 100 inches wide and over, ten per cent above or three per cent below the theoretical weight.

For all plates ordered to gauge there will be permitted an average excess of weight over that corresponding to the dimensions on the order equal in amount to that specified in the following table:

9. TABLE OF ALLOWANCES FOR OVERWEIGHT FOR RECTANGULAR PLATES WHEN ORDERED TO GAUGE.

Plates will be considered up to gauge if measuring not over 1-100 inch less than the ordered gauge.

The weight of 1 cubic inch of rolled steel is assumed to be 0.2833 pound.

PLATES ¼ INCH AND OVER IN THICKNESS.

Thickness of plate. Inch.	Width of plate. Up to 75 inches. Per Cent.	75 to 100 inches. Per Cent.	Over 100 inches. Per Cent.	Over 115 inches. Per Cent.
1/4	10	14	18	....
5/16	8	12	16	....
3/8	7	10	13	17
7/16	6	8	10	13
1/2	5	7	9	12
9/16	4 1/2	6 1/2	8 1/2	11
5/8	4	6	8	10
Over 5/8	3 1/2	5	6 1/2	9

PLATES UNDER ¼ INCH IN THICKNESS.

Thickness of plate. Inch.	Width of plate. Up to 50 inches. Per cent	50 inches and above. Per cent.
1/8 up to 5/32	10	15
5/32 " 3/16	8 1/2	12 1/2
3/16 " 1/4	7	10

10. BRANDING.

Each sheet shall be stamped with the melt number and maker's name, and the test specimens cut from it shall be stamped with separate identifying marks or numbers, as may be specified by the purchaser.

11. INSPECTION.

The inspector, representing the purchaser, shall have all reasonable facilities afforded to him by the manufacturer to satisfy him that the finished material is furnished in accordance with these specifications.

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SPECIFICATIONS FOR IRON LOCOMOTIVE BOILER TUBES.

Adopted in 1894. Revised June, 1904.

1. Tubes are to be made of knobbled, hammered charcoal iron, lap-welded.

2. Tubes must be of uniform thickness throughout, except at weld, where an additional thickness of .015 will be allowed. They must be circular within .02 inch, and the mean diameter must be within .015 inch of the size ordered. They must be within .01 inch of the thickness specified and not less than the length ordered, but may exceed this by .125 inch.

3. The minimum weights for tubes of various diameters and thicknesses are given in the following table:

Outside Diameter.	Nominal B. W. G.	Thickness M. M. G.	Minimum weight per foot.
		Inches.	Lbs.
1¼ inch	No. 13	.095	1.65
	" 12	.110	1.89
	" 11	.125	2.07
	" 10	.135	2.29
2 inch	" 13	.095	1.91
	" 12	.110	2.17
	" 11	.125	2.38
	" 10	.135	2.64
2¼ inch	" 13	.095	2.16
	" 12	.110	2.46
	" 11	125	2.70
	" 10	.135	2.99
2½ inch	" 12	.110	2.73
	" 11	.125	3.02
	" 10	.135	3.37

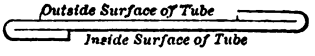
SURFACE INSPECTION.

4. Tubes must have a smooth surface, free from all laminations, cracks, blisters, pits and imperfect welds. They must be free from bends, kinks and buckles, and from evidence of unequal contraction in cooling or injury in manipulation.

PHYSICAL TESTS.

5. Bending Tests.— Strips ½ inch in width by 6 inches in length, planed lengthwise from tubes, after having been heated to a cherry red and quenched in water at 80° F., shall bend in opposite directions at each end, as shown in sketch below, without cracks or flaws, and when nicked and broken by slight blows, these strips must show a fracture wholly fibrous.

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6. EXPANDING TEST.— Sections of tubes 12 inches long shall be heated a length of 5 inches to a bright cherry red in daylight and then placed in a vertical position and a smooth taper steel pin at blue heat will be driven into the end of the tube by light blows of a 10-pound hammer. Under this test the tube must stretch to 1⅛ times its original diameter without splitting or cracking. The pin used shall be of tool steel tapered 1½ inches to the foot. In making this test, care must be taken to see that the end of the tube is smoothly trimmed.

7. One tube is to be tested, as required in paragraphs 5 and 6, in each lot of 250 tubes or less.

8. CRUSHING TEST.— A section of tube 2½ inches long, when placed vertically on the anvil of a steam hammer and subjected to a series of light blows, must crush to a height of 1⅛ inches without splitting in either direction and without cracking or bending at weld.

9. HYDRAULIC TEST.— Before shipping, each tube must be tested by manufacturer to 500 pounds per square inch, and each tube must be plainly marked in the middle: "Knobbled charcoal, tested to 500 pounds pressure."

10. In addition to the above tests, tubes which, when inserted into boilers, split or break while being expanded or beaded, and also individual tubes which fail to pass surface inspection will be rejected and returned to the makers at their expense.

11. ETCHING TEST.— In case of doubt as to the quality of material, the following test shall be made to detect the presence of steel. A section of tube, turned or ground to a perfectly true surface on the end, will be polished free from dirt or cracks, and the end of the tube will be suspended in a bath of nine parts water, three parts sulphuric acid and one part hydrochloric acid. The bath will be prepared by placing water in a porcelain dish, adding the sulphuric and then the hydrochloric acid. The chemical action must be allowed to continue until the soft parts are sufficiently dissolved so that the iron tube will show a decided ridged surface, with the weld very distinct, while the steel tube will show a homogeneous surface.

SPECIFICATION FOR SEAMLESS, COLD DRAWN STEEL LOCOMOTIVE BOILER TUBES.

1. Tubes are to be cold drawn, seamless and made of open hearth steel. It is desired that the steel from which the tubes are manufactured should have the following chemical composition:

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	Per cent.
Carbon	.15 to .20
Manganese	.45 to .55
Sulphur, below	.03
Phosphorus, below	.03

Tubes containing more than .03 phosphorus or sulphur will be rejected.

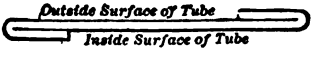
2. Tubes must be of uniform thickness throughout. They must be circular within .02 of an inch and the mean diameter must be within .015 inch of the size ordered. They must be within .01 inch of the thickness specified and not less than the length ordered, but may exceed this by .125 inch. They must be free from bends, kinks and buckles.

3. The minimum weights of the tubes of various diameters and thicknesses are given in the following table:

Outside Diameter.	Nominal B. W. G.	Thickness M. M. G.	Minimum weight per foot.
		Inches.	Lbs.
1¾ inch	No. 13	.095	1 69
	" 12	.110	1.92
	" 11	.125	2.15
	" 10	135	2.29
2 inch	" 13	.095	1.91
	" 12	.110	2.19
	" 11	.125	2.47
	" 10	.135	2 65
2¼ inch	" 13	.095	2.16
	" 12	.110	2.48
	" 11	.125	2.80
	" 10	.135	3.01
2½ inch	" 12	.110	2.73
	" 11	.125	3.04
	" 10	.135	3.41

PHYSICAL TESTS.

4. Bending Test.— Strips ½ inch in width by 6 inches in length, planed lengthwise from tubes, after having been heated to a cherry red and quenched in water at 80 degrees F., shall bend in opposite directions at each end, as shown in sketch below without cracks or flaws.



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5. EXPANDING TEST.— Sections of tubes 12 inches long shall be heated a length of five inches to a bright cherry red in daylight and then placed in a vertical position and a smooth taper steel pin at blue heat will be driven into the end of the tube by light blows of a 10-pound hammer. Under this test the tube must stretch to 1⅛ times its original diameter without splitting or cracking. The pin used shall be of tool steel tapered 1½ inches to the foot. In making this test care must be taken to see that the end of the tube is smoothly trimmed.

6. CRUSHING TEST.— A section of tube 2½ inches long, when placed vertically on the anvil of a steam hammer and subjected to a series of light blows, must crush to a height of 1⅛ inches without splitting in either direction.

7. FLATTENING TEST.— A test piece of tube 6 inches long, when flattened lengthwise cold until the sides are separated by a distance equal to the gauge of the tube, must not show any splits or cracks.

8. One tube is to be tested as required in paragraphs 4, 5, 6 and 7 in each lot of 250 tubes, or less.

9. Each tube must be subjected by the manufacturer to an internal pressure of 1,000 pounds to the square inch and must be plainly stenciled, "Seamless Steel Tubes, tested to 1,000 pounds."

SPECIFICATION FOR LOCOMOTIVE DRIVING AND ENGINE TRUCK AXLES.

MATERIAL.

1. Open-hearth steel.

CHEMICAL REQUIREMENTS.

2. Phosphorus, not to exceed..... .05 per cent.
Sulphur, not to exceed..... .05 per cent.
Manganese, not to exceed..... .60 per cent.

PHYSICAL REQUIREMENTS.

3. Tensile strength — not less than 80,000 lbs. per square inch.
Elongation in two inches — not less than 20 per cent.
Reduction in area — not less than 25 per cent.

TESTS.

4. One test per melt will be required, the test specimen to be taken from either end of any axle with a hollow drill, half-way between the center and the outside, the hole made by the drill to be not more than 2 inches in diameter nor more than 4½ inches deep. The standard turned test specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.)

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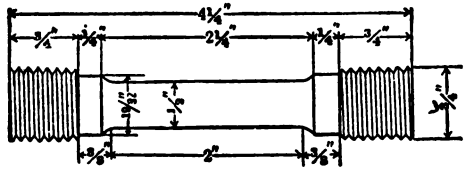


FIG. 1.

Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

5. Each axle must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch high, and have order number plainly marked with white lead.

INSPECTION.

6. All axles must be free from seams, pipes and other defects, and must conform to drawings accompanying these specifications.

7. Axles must be rough-turned all over, with a flat-nosed tool, cut to exact length, have ends smoothly finished and centered with sixty-degree centers.

8. Axles failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

SPECIFICATIONS FOR LOCOMOTIVE FORGINGS.

MATERIAL.

1. Open-hearth steel.

CHEMICAL REQUIREMENTS.

2. Phosphorus, not to exceed..... .05 per cent.
Sulphur, not to exceed..... .05 per cent.
Manganese, not to exceed..... .60 per cent.

PHYSICAL REQUIREMENTS.

3. Tensile strength — not less than 80,000 lbs. per square inch.
Elongation — not less than 20 per cent in two inches.
Reduction in area — not less than 25 per cent.

TESTS.

4. One test per melt will be required, the test specimen to be cut cold from the forging, or full-sized prolongation of same, parallel to the axis of the forging and half-way between the center and the outside.

5. The standard turned specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See

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Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

6. Each forging must have heat number and name of manufacturer plainly stamped on one end with figures not less than ⅜ inch high, and have order number plainly marked with white lead.

INSPECTION.

7. All forgings must conform to drawings which accompany these specifications, and be free from seams, pipes and other defects.

8. Any forgings failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

SPECIFICATIONS FOR STEEL BLOOMS AND BILLETS FOR LOCOMOTIVE FORGINGS.

MATERIAL.

1. Open-hearth steel.

PHYSICAL REQUIREMENTS.

2. Grade "A":
   Tensile strength, 70,000 lbs. per square inch.
   Elongation in two inches, 20 per cent.

3. Grade "B":
   Tensile strength, 80,000 lbs. per square inch.
   Elongation in two inches, 17 per cent.

CHEMICAL ANALYSIS.

4. Grade "A":

Carbon	.25 to .40 per cent.
Phosphorus, not to exceed	.06 per cent.
Sulphur, not to exceed	.06 per cent.
Manganese, not to exceed	.60 per cent.

5. Grade "B":

Carbon	.35 to .50 per cent.
Phosphorus, not to exceed	.05 per cent.
Sulphur, not to exceed	.05 per cent.
Manganese, not to exceed	.60 per cent.

TESTS.

6. One test per melt will be required, the test specimen to be cut cold from the bloom, parallel to its axis and half-way between the center and the outside. The standard turned test specimen, ½ inch in diameter and

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2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

7. Each bloom or billet must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch, and have order number plainly marked with white lead.

INSPECTION.

8. Blooms and billets must be free from checks, pipes and surface defects. Any blooms or billets chipped to a depth greater than ½ inch will be rejected.

9. Any billet or bloom failing to meet the above requirements will be rejected and held subject to disposal by manufacturers.

10. Inspector to have the privilege of taking drillings from the center of the top bloom or billet of the ingot in order to determine the amount of segregation.

Grade "A" is intended for rod straps and miscellaneous forgings.

Grade "B" is intended for driving and truck axles, connecting rods, crank pins and guides.

SPECIFICATIONS FOR FOUNDRY PIG IRON.

At the convention of 1906 specifications for foundry pig iron were proposed, and on reference to letter ballot were adopted as standard. They are as follows:

The material desired under this specification is an open-grain foundry pig conforming to and graded by the following detail specifications:

Combined carbon	.40 to .70 per cent.
Manganese	.40 to .80 per cent.
Phosphorus	.40 to .80 per cent.
Sulphur, not over	.06 per cent.

The grades are determined by the amount of silicon, in accordance with the attached schedule:

Grade No. 1, silicon	3.00 to 2.50 per cent.
Grade No. 2, silicon	2.50 to 2.00 per cent.
Grade No. 3, silicon	2.00 to 1.50 per cent.
Grade No. 4, silicon	1.50 to 1.00 per cent.

Each carload, or its equivalent, shall be considered as a unit. At least

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one pig shall be selected at random for each four tons of every carload and so as to fairly represent it.

Drillings shall be taken so as to fairly represent the fracture surface of each pig, and the sample analyzed shall consist of an equal quantity of drillings from each pig, well mixed and ground before analysis.

In case of disagreement between buyer and seller, an independent analyst, to be mutually agreed upon, shall be engaged to sample and analyze the iron. In this event one pig shall be taken to represent every two tons.

The cost of this sampling and analysis shall be borne by the buyer if the shipment is proved up to specifications, and by the seller if otherwise.

SPECIFICATIONS FOR LOCOMOTIVE CYLINDER CASTINGS, CYLINDER BUSHINGS, CYLINDER HEADS, STEAM CHESTS, VALVE BUSHINGS AND PACKING RINGS.

At the convention of 1906 the following specifications were proposed, and on reference to letter ballot were adopted as standard:

The material used in such castings must conform to the following specifications:

Silicon	1.25 to 1.60 per cent.
Phosphorus	.50 to .80 per cent.
Sulphur	.06 to .10 per cent.
Manganese	.30 to .60 per cent.
Combined carbon	.50 to .70 per cent.
Graphite carbon	2.75 to 3.25 per cent.

Tensile strength, 25,000 lbs. per sq. inch minimum.

Transverse strength, 3,000 lbs. minimum on 1¼-inch round bar, 12 inches between supports.

Deflection, .10 inch minimum on transverse test.

Shrinkage, ⅛ inch in 1 foot as a maximum.

The quality of the iron going into castings under specification shall be determined by means of the "arbitration bar." This is a bar 1¼ inches in diameter and 15 inches long. It shall be prepared as stated further on and tested transversely. The tensile test is not recommended, but in case it is called for it may be made from any of the broken pieces of the transverse test. The expense of the tensile test shall fall on the purchaser.

The tensile test piece should be prepared with threaded ends, 1¼ inches in diameter, and with a central neck of 0.8 inch diameter, 1 inch between shoulders, with a 7-32-inch radius at the shoulders, the shoulders being 1 inch in diameter and ¼ inch in length to the thread, the total length of piece being about 3½ inches.

Two sets of two bars shall be cast from each heat, one set from the

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first and the other set from the last iron going into the castings. Where the heat exceeds 20 tons an additional set of two bars shall be cast for each 20 tons or fraction thereof above this amount. In case of a change of mixture during the heat one set of two bars shall also be cast for every mixture other than the regular one. Each set of bars is to go in a single mold. The bars shall not be rumbled or otherwise treated, being simply brushed off before testing.

The transverse test shall be made on all the bars cast with supports 12 inches apart, load applied at the middle, and deflection at rupture noted. One bar of every two of each set made must fulfil the requirements to permit acceptance of the castings represented.

The bars shall be molded two in a flask and cast on end; the bottom of the bar being 1-16 inch smaller in diameter than the top, to allow for draft. Pattern shall not be rapped before withdrawing. The flask is to be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve with a mixture of 1 to 12 bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried and not cast until it is cold. The test bar shall not be removed from the mold until cold enough to be handled.

The rate of application of the load shall be from 20 to 40 seconds for a deflection of 0.10 inch.

Borings from the broken pieces of the arbitration bar shall be used for the chemical determinations. One determination for each mold shall be required.

For cylinder heads, steam chests and packing rings the silicon must run between 1.60 and 1.80 per cent, the other elements remaining as above. If cylinder castings are to be bushed from the start and also have valve bushings or false valve seats, they should be made of this latter grade of iron.

SPECIFICATIONS AND TESTS FOR CAST-IRON WHEELS.

At the convention of 1888 the following Specifications and Tests for Cast-iron Wheels were adopted as standard. (See pages 151-154, report 1888.) In 1891 these were changed to Recommendations. (See pages 160, 161, report 1891.)

In 1908 these were modified and changed to standard and the form of contract omitted.

For 33-inch Cast-iron Wheels Having a Minimum Weight of 600, 650 and 700 Pounds. For Cars of 60,000, 80,000 and 100,000 Pounds Capacity.

1. Chills must have the same inside profile as shown by M. C. B. drawings of wheel tread adopted in 1906. The inside diameter of chill must be the M. C. B. standard of 33½ inches, measured at a point 2⅝ inches from outside of tread of wheel.

2. Wheels of the same normal diameter must not vary more than one-fourth (¼) of an inch above or below the mean size measured on

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the circumference, and the same wheel must not vary more than one-sixteenth (1-16) of an inch in diameter. The body of the wheel must be smooth and free from slag, shrinkage or blowholes. The tread must be free from deep and irregular wrinkles, slag, chill cracks and sweat or beads in throat, and swollen rims.

3. The wheels must show clean gray iron in the plates, except at chaplets, where mottling to not more than one-half (½) inch from same will be permitted. The depth of pure white iron must not exceed one (1) inch nor be less than one-half (½) inch in the middle of the tread. It shall not exceed one (1) inch in the middle of the tread nor be less than three-eighths (⅜) inch in the throat for wheels having a maximum weight of six hundred (600) pounds. It shall not exceed one (1) inch in the middle of the tread nor be less than seven-sixteenths (7-16) inch in the throat for wheels having a minimum weight of six hundred and fifty (650) pounds, and shall not exceed one (1) inch in the tread nor be less than one-half (½) inch in the throat for wheels having a minimum weight of seven hundred (700) pounds. The depth of white iron shall not vary more than one-fourth (¼) of an inch around the tread on the rail line in the same wheel.

4. When ready for inspection, the wheels must be arranged in groups, all wheels of the same date being grouped together, and for each hundred wheels which pass inspection and are ready for shipment, two representative wheels shall be taken at random, one of which shall be subjected to the following tests:

The wheels shall be placed flange downward on an anvil block, weighing not less than seventeen hundred (1,700) pounds), set on rubble masonry at least two (2) feet deep, and having three supports not more than five (5) inches wide to rest upon. It shall be struck centrally on the hub by a weight of two hundred (200) pounds. For wheels having a minimum weight of six hundred (600) pounds, ten (10) blows falling from a height of nine (9) feet. For wheels having a minimum weight of six hundred and fifty (650) pounds, twelve (12) blows falling from a height of ten (10) feet, and for wheels having a minimum weight of seven hundred (700) pounds, twelve (12) blows falling from a height of twelve (12) feet. Should the test wheel stand the given number of blows without breaking in two or more pieces, the inspector will then subject the other wheel to the following test:

The wheel must be laid flange down in the sand and a channel way one and one-half (1½) inches wide and four (4) inches deep must be molded with green sand around the wheel. The clean tread of the wheel must form one side of the channel way, and the clean flange must form as much of the bottom as its width will cover. The channel way must then be filled to the top with molten cast iron, which must be hot enough, when poured, so that the ring which is formed when metal is cold shall be solid or free from wrinkles or layers. The time when the pouring ceases must be noted, and two minutes later an examination of the wheel

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must be made. If the wheel is found broken in pieces, or if any crack in the plate extends through or into the tread, the one hundred wheels represented by the tests will be rejected.

5. In case of the drop tests, should the test wheel break in two or more pieces with less than the required number of blows, then the second wheel shall be taken from the same lot and similarly tested. If the second wheel stands the test it shall be optional with the inspector whether he shall test the third wheel or not; if he does not do so, or if he does, and the third wheel stands the test, the hundred wheels shall be accepted as filling the requirements of the drop test.

6. The lower face of the weight of two hundred (200) pounds shall be eight (8) inches in diameter, and have a flat face.

7. The thickness of the flange shall be regulated by the maximum and minimum flange thickness gauges adopted by the M. C. B. Association in 1907.

8. All wheels must be numbered consecutively in accordance with instructions from the railroad company purchasing them, and shall have the number, the normal weight of the wheel, also the day, month and year when made plainly formed on the inside plate in casting, and no two wheels shall have the same number. All wheels shall also have the name of the maker and place of manufacture plainly formed on the outside plate in casting.

Wheels made to conform to these specifications should also be plainly marked M. C. B. 1907.

9. Individual wheels will not be accepted which

(1) Do not conform to standard design and measurements.

(2) Are under weight.

(3) Have physical defects described in Section 2.

Any lot of one hundred wheels submitted to test will not be accepted

(1) If wheels broken do not meet the prescribed drop test.

(2) If the wheel tested does not stand the thermal tests.

(3) If the conditions prescribed in Section 3 are not complied with.

10. All wheels must be taped with M. C. B. standard design of wheel circumference tape having numbers 1, 2, 3, 4, 5 stamped one-eighth (⅛) inch apart, the figure three (3) to represent the normal diameter, 103.67 inches circumference, the figure one (1) the smallest diameter and the figure five (5) the largest diameter.

FITTINGS FOR LUBRICATORS.

At the convention of 1906 the Committee on Locomotive Lubrication proposed a standard location of holding arm shoulder and oil and steam connection joint faces; also a system of fittings and joints for all connections. Fig. 1 shows the location for connection of joints and holding arm.

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Figs. 2, 3, 4 and 5 show pipe joints and fittings, and Fig. 1 illustrates the working sections proposed.

"In reference to joints which they were adopted as standard. They are as follows, herewith.

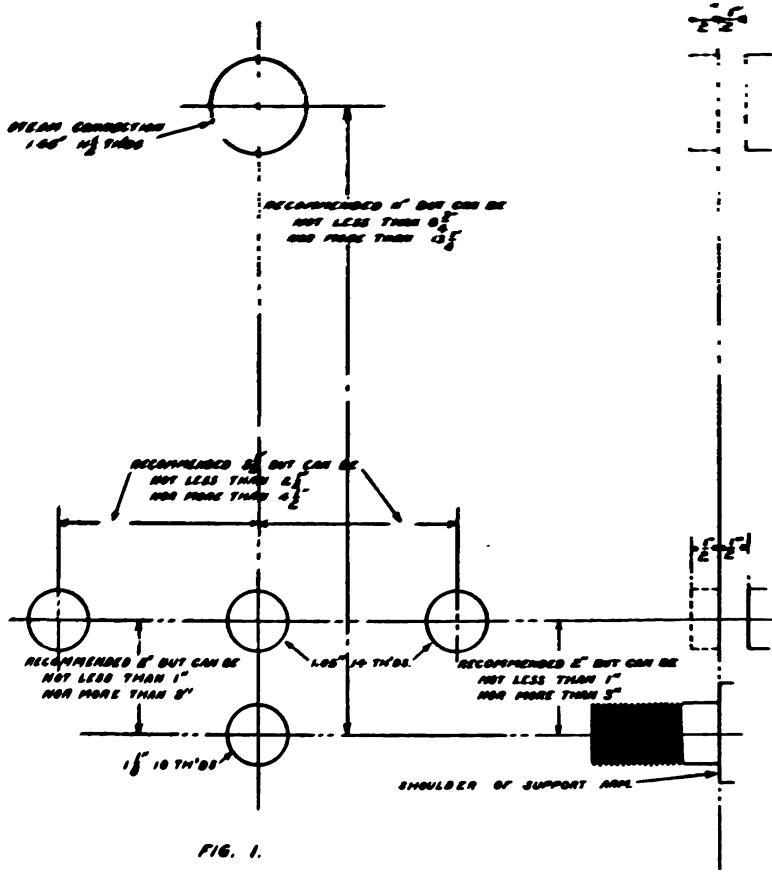


FIG. 1.

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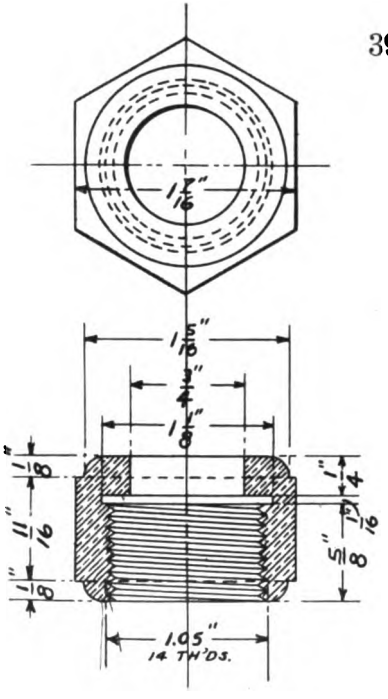


FIG. 2.

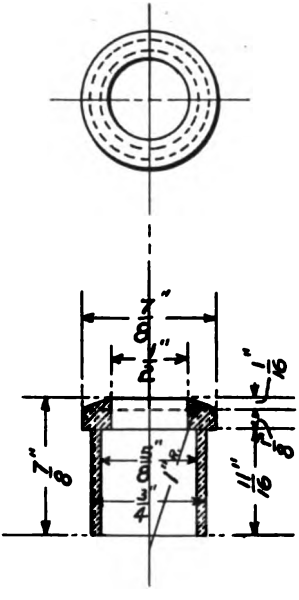


FIG. 3.

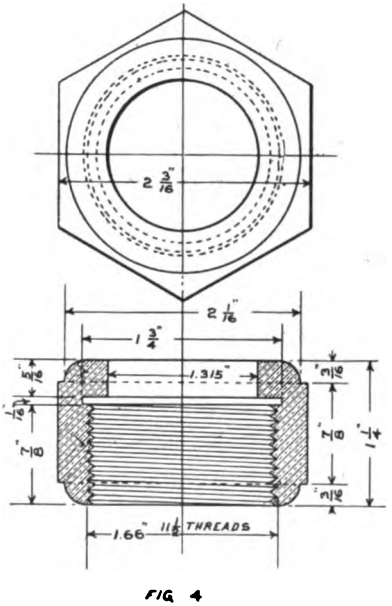


FIG. 4

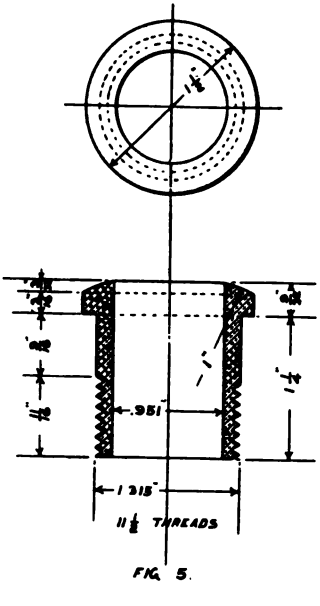


FIG. 5.

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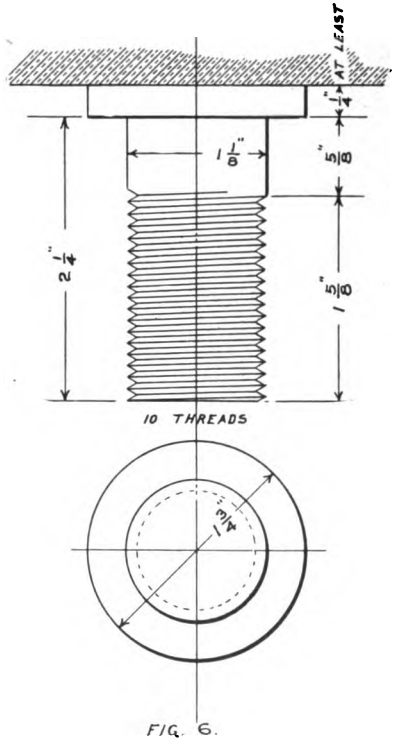


FIG. 6.

STANDARD METHOD OF CONDUCTING EFFICIENCY TESTS OF LOCOMOTIVES.

In 1894 a method of conducting tests of locomotives was submitted by a committee of the Association, and on motion adopted as a standard of the Association. (See page 200, report 1894.)

The tests are as follows:

*A. Preparations for Test and Location of Instruments.**

1. The locomotive should be put in good condition preparatory to the test. The boiler and tubes should be tight, and both the interior and exterior surfaces should be clean, and, if possible, free from scale. There should be no lost motion in the valve gear, and the valves should be set properly. No change in the engines should be allowed during the progress of a series of tests, unless so ordered for the purposes of the trial.

A glass water-gauge should be fitted to the boiler, if not already provided, and side of it there should be a graduated scale to assist in

* The directions here given apply largely to both shop and road tests, but especially the latter.

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correcting water quantities, caused by change of inclination of the boiler, and difference of levels when beginning and ending a test. The notches on the quadrant should be marked by large figures, so that they can be read by the cab assistant. The throttle valve lever should be provided with a scale so as to show the degree of opening of the throttle valve.

The point of cut-off of the valves should be determined for each notch in the quadrant.†

2. The valves and pistons should be tested for leakage with the engine at rest. The steam valve can be tried by setting the engine so that the valve on one side will be at the center of its throw, in which position both ports are usually covered, and pulling open the throttle valve, blocking the drivers if there is a tendency for the engine to be set in motion. Leakage of the valve, if any occurs, will show itself by escaping at the open cylinder cocks. The tightness of the piston may be tested by setting the engine so that it makes steam, blocking the drivers and opening the throttle valve. This should be tried first on one cylinder and then on the other, and, if desired, it may be tried with the pistons at various points in the stroke. The leakage, if any occurs, will be shown at the open cylinder cock.

3. The following instruments should be verified or calibrated: Steam gauges, draft gauge, pyrometer, thermometers for calorimeter and feed-water, water meter, tank, revolution counter, indicator springs, dynamometer springs and dynamometer recording mechanism. The radiation loss on the steam calorimeter should be determined, or the normal readings ascertained, and the quantity of steam which passes through the instrument in a given time should be measured.

4. The quantities of steam used by the various auxiliaries of the locomotive can be determined by noting the change in weight of the engine standing upon scales while they are each in use under the usual conditions for known times. Similarly leakage of water and steam can be determined. The quantities can then be properly deducted from the total water used.

5. To facilitate the measurement of coal and the determination of the quantity used during any desired period of the run, it is desirable to provide a sufficient number of sacks of a size holding a weight of, say, 100 pounds, and weigh the coal into these sacks preparatory to starting on the test. If desired, the sacks may be numbered to facilitate the accuracy of record.

6. The instruments and other apparatus that should be provided and their locations are as follows:

To facilitate the work of operating the indicators and reading the instruments at the front end, the smoke-box should be surrounded with a wooden fence, or "pilot-box," as it may be called, resting on the top of the cow-catcher, and extending back far enough to inclose also the sides

† See appendix for description of valve diagram apparatus used on Norfolk & Western Railway.

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of the cylinders. This box is floored over above the cylinder heads, and the inclosure thus provided forms a convenient place for the accommodation of the assistants at this end of the locomotive, and it affords them some measure of protection against wind and rain, as also the joltings and vibrations due to rapid travel.

A special steam-gauge with a long siphon is to be used for registering the boiler pressure. It can best be located on the left-hand side of the cab.

The indicator apparatus which is most suitable consists of a three-way cock for the attachment of the indicators, and some form of pantagraph or other correct reducing motion for the driving rig. The pipes leading from the cock to the cylinder should be ¾ inch diameter inside, and they should connect into the side of the cylinder rather than into the two heads. The indicator should also be piped so that a steam-chest diagram can be drawn by it, and from this the steam-chest pressure determined. Sharp bends in the pipe should be avoided, and they should be well covered, to intercept radiation. The three-way cock should be provided with a clamp rigidly secured to the cylinder, and thus overcome any tendency of the indicators to move longitudinally with reference to the driving rig. Absolute rigidity is highly essential in this particular. Two forms of pantagraph motion are shown in Figs. 1 and 2. In both of these the reduced motion is transmitted to the indicator through a light rod, working horizontally. By this means a cord eight or ten inches in length is sufficient for connection to the indicator. Care should be taken to set the instrument in such a position that the cord pin in the end of the rod travels in a direction pointing to the groove in the paper drum. Pantagraph motions arranged as noted are preferable to the common pendulum and quadrant reducing mechanism, with its long stretch of cord. For another type of correct reducing motion see appendix.

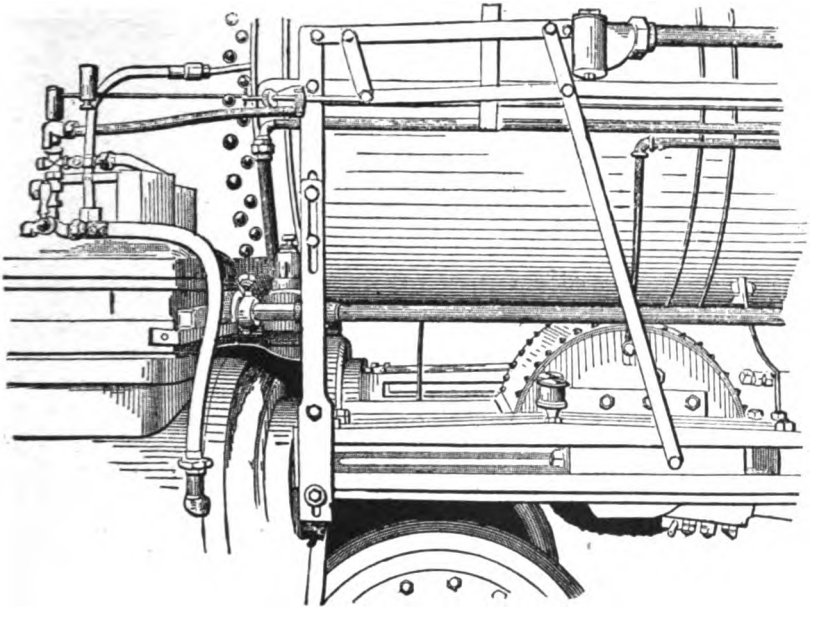
A draught gauge consisting of a U tube containing water, properly graduated in inches, should be placed in the cab and connected to the smoke-box by a ⅜-inch pipe. This long pipe steadies the water, and the readings can be taken by the cab assistant.

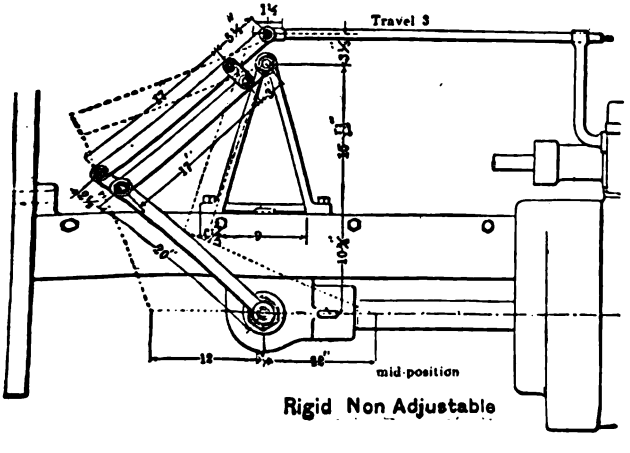
A pyrometer for showing the temperature of the escaping gases should be used in a position below the tip of the exhaust nozzles.

The calorimeter should be attached either to the steam dome at a point close to the throttle opening or to the steam passages in the saddle casting on one side, according as it is desired to obtain the character of the steam at one point or the other. The former location is preferred by the committee. A perforated ½-inch pipe should be used for sampling and conveying the steam to the calorimeter pipe. For descriptions of various forms of calorimeters which are adapted to locomotive use, see Trans. A. S. M. E., Vol. X, page 327; Vol. XI, page 790; Vol. XII, page 825.

The water meter should be attached to the suction pipe of the injector, and located at a point where it can be conveniently read when the locomotive is running. It should be provided with a check valve to

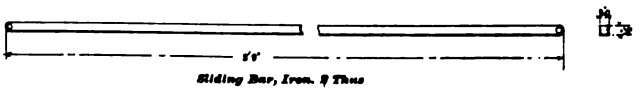
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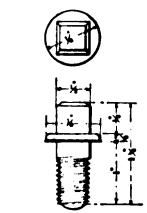


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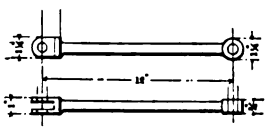
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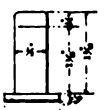
Sliding Bar, Iron. 2 Thus



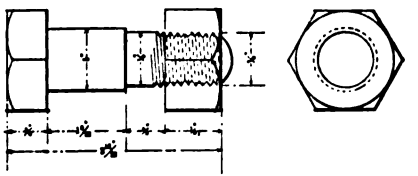
Clamp Screw, Iron. 2 Thus



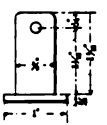
Connecting Rod, Iron. 2 Thus



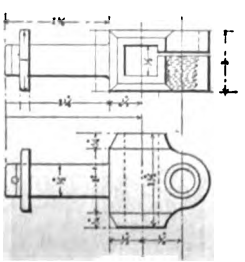
Link Pin, Iron. 2 Thus



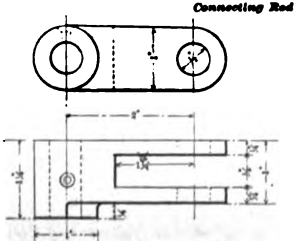
Indicator Lever Bolt, Iron. 2 Thus



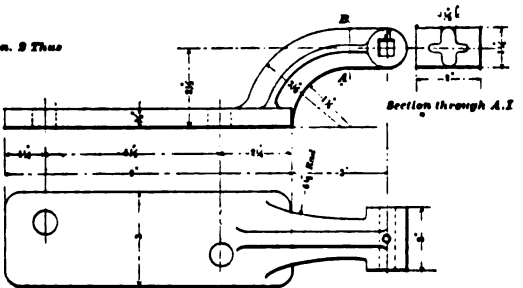
Connecting Rod Pin, Iron. 2 Thus



Sliding Bar Clamp, Brass. 2 Thus



Connecting Link, Brass. 2 Thus



Sliding Bar Guide, Cast Iron. 4 Thus

FIGURE 2.

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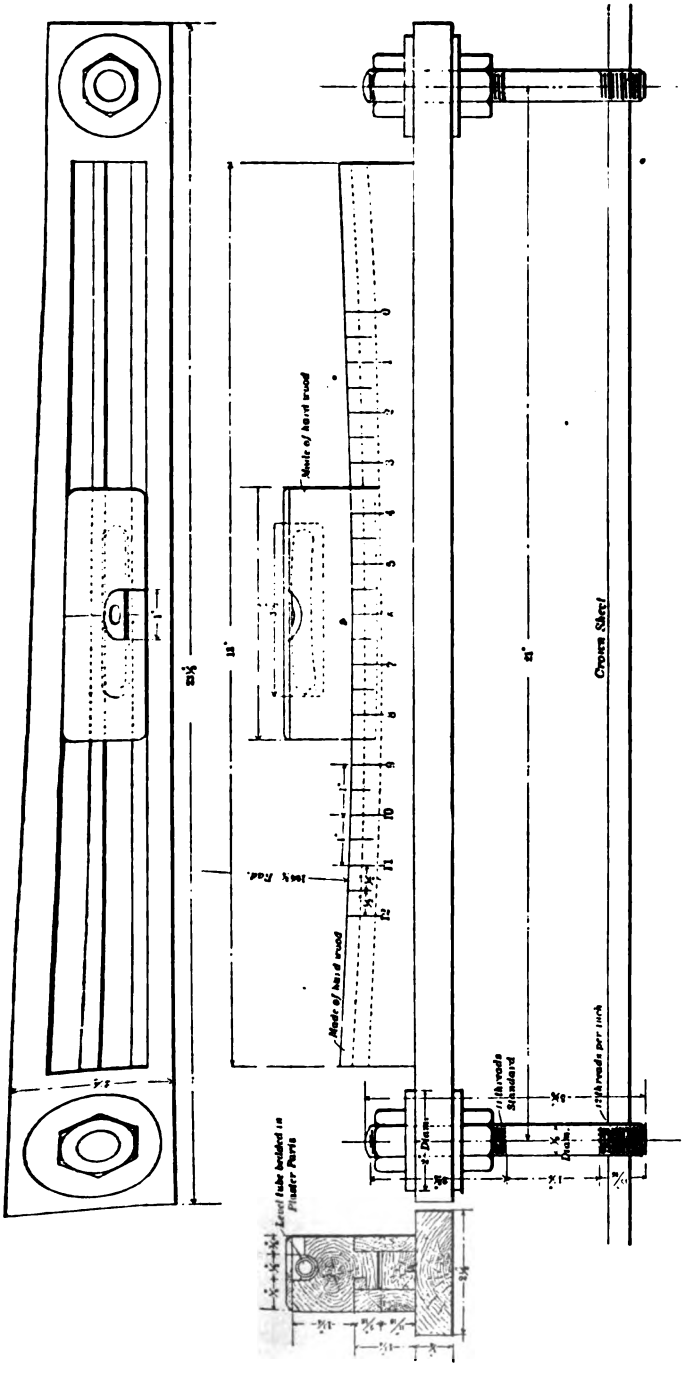


FIGURE 4.

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prevent hot water from flowing back to it from the injector and a strainer to intercept foreign material.

To measure the depth of the water in the tank a metallic float should be used carrying a vertical tube which slides upon a graduated rod, the lower end of which rests upon the bottom of the tank. This should be placed at the center of gravity of the water space. If the desired location can not be used, provision should be made for ascertaining the level or inclination of the tank. The best device for this purpose is a plumb line of a certain known length, provided at the bottom with a double horizontal scale having one set of divisions parallel to the side of the tank and the other set at right angles to it. From the readings on these scales referred to, the length of the line, the level of the tank in both directions can be ascertained. A similar device should be attached to the boiler to correct for the variation of its inclination.* The plumb line may be conveniently attached for this purpose at some point near the front end.

The revolution counter should be placed near the front end of the engine, in plain view of the pilot-box. It is operated through a belt from the driver axle. This recommendation applies to that form of counter which shows at a glance the exact speed in revolutions per minute.

A stroke counter should be provided for showing the number of strokes made by the air-pump.

Electric connection should be made between the dynamometer car and cab, so that dynamometer records and indicator diagrams may be taken simultaneously. Another desirable provision is a speaking-tube leading from the dynamometer car to the locomotive cab, and one also to the pilot-box.

7. It is needless, except for a complete record of directions for preparatory work, to call attention to the desirability of having the test, and especially the road test, made under the supervision of a competent person, who is not only familiar with the details of the testing, but also with the proper method of firing and mechanical operation of the locomotive. This is a most important factor, for it is only the clear-headed and able experimenter who is likely to obtain satisfactory work in this most difficult department of engineering tests.

The conductor of the test is best able to determine the number of assistants required, the various duties of the men, and the manner of making records. In general, three (3) men are sufficient to conduct a locomotive test, one (1) being at each cylinder, and one (1) in the cab for taking records.

The men at the cylinders will take indicator diagrams, and one will read the revolution counter and the pyrometer. The indicator papers will be numbered in consecutive order for each cylinder before the test begins, and when the diagram is taken the papers will be deposited through a slot in a box near each assistant.

* See appendix for description of special devices used on the Norfolk & Western Railway for this purpose.

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The cab assistant notes the time of leaving and arriving at stations, the position and time of opening and closing the throttle, the time of taking indicator diagrams, for which he shall determine the time and give the signal by any effective means; the time of blowing off, the time the blower is applied, the number of applications of the injector, the position of the reverse lever, the steam pressure, the draught gauge, the time of passing important stations, the readings of the water glass, meter and air-pump counter, the number of sacks of coal used, the reading of the tank float, the temperature of the feed-water and atmosphere, the direction and force of the wind, the condition of the rail and state of the weather. Many of these readings are as nearly as possible simultaneous with the signal for taking indicator diagrams, and one experienced man in the cab will have no difficulty in entering all of these records in a note-book properly prepared with ruled columns and headings. In case of short stops at stations, one of the men at the indicators can take the tank float observations, or any observation that is advisable at stations. The weights of coal placed upon the tender have been checked by these two persons when weighing it out to the engine. One man takes the level of the boiler at stopping-places where this is required.

When the calorimeter and smoke-box gas samples are used another assistant is required.

In the dynamometer car two (2) men are required, who record the time of each start and stop, the time of passing each station and mile-post, time of taking each indicator diagram as obtained from the signal given by the cab assistant, and all these events are marked on the dynamometer paper. These men, as well as one of the engine assistants, will note the direction and force of the wind, the temperature of the atmosphere and condition of the weather.

8. It is of great importance, after the preparatory work has been accomplished, that a preliminary run be made with the locomotive, in order to fairly test the apparatus and to accustom the men to their duties.

B. The Dynamometer Car.

With a suitable dynamometer car the force required to move the train, or the pull upon the drawbar, is registered upon a strip of paper traveling at a definite rate per mile. The scale upon which this diagram is drawn should be as large as is possible within reasonable limits. A scale of ¼ inch per 1,000 pounds pull is suitable, as the maximum registered pull rarely exceeds 30,000 pounds.

The height of the diagram should be measured from a base line drawn upon the paper by a stationary pen, so located that when no force is exerted upon the drawbar the base line should coincide with zero pull.

The apparatus should be arranged to make a record of time marks in connection with the curve showing the pull. A chronometer should be provided having an electric circuit-breaker, by means of which a mark is made on the dynamometer paper every five (5) seconds. A better appa-

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ratus may be used in which a continuous speed curve is traced upon the paper parallel to the curve of pull. The ordinates of this curve, measured from a base line, give the speeds desired.

The location of mile-posts and other points along the route should be fixed upon the dynamometer paper by employing an additional pen, and operating it by means of electric press buttons, which are placed at convenient points in the car.

As already noted, a similar device should be provided for marking upon the dynamometer paper the time of taking indicator diagrams.

The rate of travel of the paper per mile should be such that one inch measured upon the diagrams represents 100 feet for short-distance work, and for long-distance work ½ inch to ¼ inch should be used to represent 100 feet of track. The driving mechanism for the paper should be so arranged that it can be changed to give these three proportions. It is necessary to have all the registering pens located upon the same transverse line at a right angle with the direction of the movement of the paper in order that simultaneous data may be recorded.

C. Method of Conducting the Road Test.

The locomotive having been brought to the train, the steam pressure being at or near the working point, the fire being clean and in good condition, the ash-pan being also clean, observations are taken, say, five (5) minutes before starting time, of the thickness and condition of the fire, the height of water in the boiler, the depth in the tank, the levels, the water meter and the air-pump counter, and thereafter the regular observations are carried forward, and coal is fired from the weighed sacks.

Indicator diagrams should be taken as frequently as possible, the intervals between them being not over two minutes.

Other regular observations should be taken at close intervals. Calorimeter readings, when taken, should be continued for at least five (5) minutes at one minute intervals.

At water stations careful records should be obtained of water heights and levels of boiler and tank.

As the end of the route is approached, the fire should be burned down so as to leave the same amount and the same condition as at the start. When the end is finally reached the fire should be raked and its condition carefully noted. If it differs from that which obtained at the beginning, an estimated allowance must be made for such difference.

At the close of the test the height of water in the boiler should be the same as at the beginning, or, if not, the difference, corrected for inclination of the boiler, should be allowed for.

During the process of weighing the coal into the sacks numerous samples should be obtained and placed in a covered box, and a final sample of these selected. This is to be dried and subjected to chemical analysis and calorimeter test. The sample is weighed before and after drying, and data obtained for determining the weight of dry coal used dur-

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ing the test. The temperature of the feed-water can be best taken at the tank cock, in order to obtain that of a mixed sample.

The duration of the road test is the length of time which the throttle valve is open.

D. The Data and Results.

The data and results of the road test may be tabulated in the form given in Table No. 1. This form corresponds in general with that recommended for shop test, namely, Table No. 2.

TABLE No. 1.

Data and Results of Road Test on....Engine, Made....189 .

General dimensions, etc. (to be accompanied by a complete description of engine with drawings and dimensions, also of train and route):

1. Kind of engine .....
2. Size of cylinders.....
3. Clearance of cylinders .....per cent
4. Area of heating surface .....sq. ft.
5. Area of grate surface.....sq. ft.
6. Size of exhaust nozzles .....inches
7. Average weight of locomotive and tender (including water)....tons
8. Number of cars .....
9. Weight of cars .....tons
10. Length of route .....miles
11. Number of ton-miles of train load .....ton-miles
12. Number of ton-miles of total load.....ton-miles
13. Schedule time of trips.....

Total Quantities.

14. Duration or time throttle valve is open .....hours
15. Weight of dry coal burned .....lbs.
16. Weight of water evaporated, corrected for moisture in the steam and loss at injector*.....lbs.
17. Weight of ashes and refuse taken from ash-pan.....lbs.
18. Weight of cinders from smoke-box .....lbs.
19. Percentage of ash as found by coal calorimeter test.....per cent
20. Total heat of combustion as found by calorimeter test ....B. T. U.
21. Results of chemical analysis of coal .....

Power Data.

22. Mean effective pressure, H. P. cyls.....lbs.
23. Mean effective pressure, L. P. cyls.....lbs.
24. Average revolutions per minute.....rev.
25. Indicated horse-power, H. P. cyls.....H. P.

* Should be corrected for steam used by calorimeter, air pump, blower, safety valve and whistle, to find cylinder results — line 56.

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26. Indicated horse-power, L. P. cyls.....H. P.
27. Indicated horse-power, whole engine.....H. P.
28. Pull on drawbar.....lbs.
29. Dynamometer horse-power .....H. P.

Averages of Observations of Instruments.

30. Average boiler pressure .....lbs.
31. Average steam-chest pressure .....lbs.
32. Average temperature of smoke-box..... °
33. Average drought suction..... "
34. Average temperature of feed-water..... °
35. Average temperature of atmosphere..... °
36. Average percentage of moisture in the steam.....per cent
37. Maximum percentage of moisture in the steam.....per cent
38. Weather, wind, etc.....

Other Data.

39. Average position of throttle.....
40. Average position of reversing lever.....
41. Average speed in miles per hour.....
42. Maximum speed in miles per hour.....
43. Number of stops.....
44. Average number of strokes of air pump per minute.....
45. Total estimated weight of steam used by air pump per hour.....lbs.
46. Estimated loss of steam at safety valve per hour.....lbs.
47. Estimated loss of steam at whistle per hour.....lbs.
48. Estimated weight of steam used by blower per hour.....lbs.
49. Estimated loss of steam at calorimeter per hour.....lbs.

Hourly Quantities.

50. Weight of dry coal burned per hour.....lbs.
51. Weight of dry coal burned per hour per square foot of grate surface .....lbs.
52. Weight of coal burned per square foot of heating surface.....lbs.
53. Weight of water evaporated per hour.....lbs.
54. Equivalent weight of water evaporated per hour with feed-water at 100° and pressure 70 lbs.....lbs.
55. Equivalent weight of water from 100° at 70 lbs. evaporated per square foot of heating surface.....lbs.
56. Weight of water consumed by engine cylinder (line 53, less sum of lines 45, 46, 47, 48 and 49).....lbs.

Principal Results — Complete Engine and Boiler.

57. Coal consumed per I. H. P. per hour.....lbs.
58. Coal consumed per dynamometer horse-power per hour.....lbs.
59. Coal consumed per ton-mile of train load.....lbs.

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60. Coal consumed per ton-mile of total load.....lbs.
61. Weight of standard coal consumed per I. H. P. per hour.....lbs.
62. Weight of standard coal consumed per dynamometer horse-power per hour.....lbs.
63. Weight of standard coal consumed per ton-mile of train load....lbs.
64. Weight of standard coal consumed per ton-mile of total load.....lbs.

Boiler Results.

65. Water evaporated per pound of coal .....lbs.
66. Equivalent evaporation per pound of coal from and at 212°.....lbs.
67. Equivalent evaporation per pound of combustible from and at 212° .....lbs.
68. Heat imparted to each pound of steam used from average temperature of feed at average steam pressure in British thermal units.....

Cylinder Data.

69. Mean initial pressure above atmosphere.....lbs.

		H. P. Cyl.	L. P. Cyl.
70.	Cut-off pressure above zero.....lbs.	.....	.....
71.	Release pressure above zero .....lbs.	.....	.....
72.	Compression pressure above zero.....lbs.	.....	.....
73.	Lowest back pressure above or below atmosphere .....lbs.	.....	.....
74.	Proportion of forward stroke completed at cut-off	.....	.....
75.	Proportion of forward stroke completed at release	.....	.....
76.	Proportion of return stroke uncompleted at compression	.....	.....
77.	Mean effective pressure (lines 22 and 23) lbs.	.....	.....

Cylinder Results.

78. Total water consumed per indicated horse-power per hour, corrected for moisture in steam.....lbs.
79. Water consumed per I. H. P. per hour by cylinders alone (from line 56).....lbs.

		H. P. Cyl.	L. P. Cyl.
80.	Steam accounted for by indicators at cut-off.lbs.	.....	.....
81.	Steam accounted for by indicator at release.lbs.	.....	.....
82.	Proportion of feed-water used by cylinders (line 79) accounted for at cut-off.....	.....	.....
83.	Proportion of feed-water used by cylinders accounted for at release.....	.....	.....
84.	Total heat supplied by boiler to cylinders per hour in British thermal units.....	.....	.....

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		H. P. Cyl.	L. P. Cyl.
85.	Total heat supplied by boiler to cylinders per minute per indicated horse-power in British thermal units.....	.....	.....
86.	Total heat supplied by boiler to cylinders per minute per dynamometer horse-power in British thermal units	.....	.....

The following form for the tabulation of the results of locomotive tests will be found convenient. They can, of course, be modified to suit any method of testing, whether standard or not:

LOCOMOTIVE TESTS — GENERAL RESULTS.

.....*Railroad Co.*

.....*Tests of Locomotive No.....*, *between*.....

and.....*Distance*.....*Miles. Train No*.....

.....*Bound.* ....., *18*....

Kind of Coal..... *Coal Analysis*.....

Calorimetric Value of Coal.....

Trip No.....

Date .....

Left .....at.....

Arrived .....at.....

Left .....at.....

Arrived .....at.....

1. Weather .....
2. Mean temperature of atmosphere.....
3. Direction of wind.....
4. Velocity of wind, miles per hour.....
5. Condition of rails.....
6. Weight of train in tons of 2,000 lbs., including locomotive, tender, passengers and freight.....
7. Weight of train in tons of 2,000 lbs., excluding the locomotive and tender .....
8. Equivalent number of standard cars at.....tons each.....
9. Size of exhaust nozzle, single or double.....
10. Maximum boiler pressure by gauge.....
11. Minimum " " " " .....
12. Average " " " " ....
13. Prevailing position of throttle (wide open = 1.00).....
14. " " " reverse lever (notch) .....
15. " points of cut-off .....
16. Schedule time in motion.....
17. Actual " " " .....
18. Time made up in minutes.....

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19. Aggregate intermediate stops, minutes.....
20. Time during which power was developed, or throttle open.....
21. Maximum number of revolutions per minute.....
22. Minimum number of seconds per mile.....
23. Maximum rate of speed, miles per hour.....
24. Average speed, miles per hour.....
25. Actual weight of coal fired.....
26. Moisture in coal, percentage.....
27. Dry coal fired.....
28. Actual weight of wood used.....
29. Total weight of coal fired (wood added at .4).....
30. Weight of refuse in fire-box and ash-pan.....
31. " unconsumed coal recovered from fire-box and ash-pan.....
32. Total weight of coal consumed (Item 29-31).....
33. Net weight of ashes in fire-box and ash-pan.....
34. Weight of cinders (sparks) in smoke-box.....
35. Percentage of ash in coal.....
36. " " cinders (sparks).....
37. " " total refuse.....
38. Percentage of combustible consumed.....
39. Weight of combustible utilized.....
40. Number of miles run per ton (2,000 lbs.) of coal.....
41. " " pounds of coal used per mile.....
42. Coal used per ton of train per 100 miles.....
43. " " " car-mile.....
44. Average weight of coal burned per square foot of grate surface per hour .....
45. Total coal per indicated horse-power developed per hour.....
46. Average temperature of feed-water.....
47. Weight of water drawn from tender.....
48. Waste of injector, leakage, etc.....
49. Weight of water apparently evaporated (Item 47-48).....
50. Percentage of moisture in steam.....
51. Water actually evaporated, corrected for quality of steam.....
52. Actual evaporation per pound of total coal.....
53. Equivalent evaporation from and at 212° per pound of coal.....
54. " " " " " " " " " " combustible.
55. Water used per ton of train per 100 miles.....
56. " " " car-mile .....
57. " " " hour while developing power.....
58. " " " indicated horse-power per hour.....
59. " " " sq. ft. of heating surface, from and at 212°.....
60. " " " " " " grate " " " " .....
61. Maximum indicated horse-power developed.....
62. Average " " " .....
63. Dry steam used per indicated horse-power, per hour, per indicator diagram .....

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64. Average number of sq. ft. of heating surface per indicated horse-power
65. Average number of indicated horse-power per sq. ft. of grate surface.
66. Prevailing temperature in smoke-box while using steam.....
67. " draft in smoke-box while using steam, in inches of water.

SHOP TEST.

A. Preparation and Location of Instruments.

In preparing for a shop test the preparations described for the road test should be followed so far as the nature of the test requires. When run as a stationary engine the locomotive is not circumscribed by the conditions of road service, and many provisions required on the road are unnecessary. It is unnecessary to determine the quantity of steam consumed by the air pump and auxiliaries, for these are not brought into use on the shop test; and no occasion exists for finding the quantity lost at the safety valve, for on the continuous shop run the steam pressure can be maintained at a uniform point, and blowing off readily prevented. It is unnecessary to use sacks for the convenient measure of coal, because the coal can be readily weighed up in lots as fast as needed for the test. It is unnecessary to provide a "pilot-box," and no fixed location of the instruments is required, as on the road test. The feed-water may be weighed before it is supplied to the tank, and the tank may be used in this case as a reservoir, the float showing its depth. The meter would thus be unnecessary as the principal instrument of measurement, but a meter is in all cases useful as a check upon this most important element in the data. The long indicator pipes required on the road test may be dispensed with, and one indicator applied close to each end of the cylinder, a practice much to be preferred to the use of a three-way cock and the single indicator. The dynamometer car is not required, but its equivalent should be provided, consisting of a dynamometer which registers the pull on the drawbar in the same manner as the device used on the road.

The number of assistants required on a shop test is less than that needed for a road test. A good test can be made with four (4) assistants, distributed as follows:

One assistant for operating indicators.

One assistant for measuring water.

Two (2) assistants for general observations and coal measurement.

B. Conditions of Test.

The test should be continued for a run of at least two (2) hours from the time normal conditions have been established.

At the close of the test the water height in the boiler and the height of water in the tank should be the same as at the beginning, or proper corrections made for any differences which may exist.

The fire-box and ash-pit are then cleaned, and such unburnt coal as may be contained in the refuse is separated, weighed and deducted from

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the total weight of coal fired. The balance of the refuse is weighed, as also the cinders removed from the smoke-box.

During the progress of the test samples of the various charges of coal should be obtained, and at its close a final sample of these should be selected, dried and subjected to chemical analysis and calorimeter test. The weight of the sample as taken before and after drying to ascertain the weight of moisture contained in the fuel.

C. The Data and Results.

The data and results of the shop test can best be arranged in the manner indicated in Table No. 2. So far as these are in common with the data and results obtained on the road test, the forms used on both kinds of test are identical.

TABLE No. 2.

Data and Results of Shop Test on....Engine, made.....189.....

General dimensions, etc. (to be accompanied by a complete description, with drawings and full dimensions).

1. Kind of engine.....
2. Size and clearance of cylinders.....
3. Area of heating surface.....
4. Area of grate surface.....
5. Diameter of exhaust nozzles.....

	Total Quantities.	Whole Run.
6.	Duration .....hrs.	.....
7.	Weight of dry coal burned, including .4 weight of wood.lbs.	.....
8.	Weight of water evaporated corrected for moisture in the steam .....lbs.	.....
9.	Weight of ashes and refuse from ash-pan.....lbs.	.....
10.	Weight of cinders from smoke-box.....lbs.	.....
11.	Percentage of ash as found by calorimeter test....per cent	.....
12.	Total heat of combustion per lb. coal as found by calorimeter test.....B. T. U.	.....
	Power Data.	
13.	Mean effective pressure, high-pressure cylinders.....lbs.	.....
14.	Mean effective pressure, low-pressure cylinders.....lbs.	.....
15.	Average revolutions per minute.....rev.	.....
16.	Indicated horse-power, high-pressure cylinders.....H. P.	.....
17.	Indicated horse-power, low-pressure cylinders.....H. P.	.....
18.	Indicated horse-power, total.....H. P.	.....
19.	Pull on drawbar .....lbs.	.....
20.	Dynamometer horse-power .....H. P.	.....
	Averages of Observations.	
21.	Average boiler pressure.....lbs.	.....
22.	Average steam-chest pressure.....lbs.	.....

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		Whole Run
23.	Average temperature of smoke-box.....°	.....
24.	Average draught suction....."	.....
25.	Average temperature of feed-water .....°	.....
26.	Average temperature of atmosphere.....°	.....
27.	Average percentage of moisture in the steam....per cent	.....
28.	Maximum percentage of moisture in the steam...per cent	.....

Hourly Quantities.

29.	Weight of dry coal burned per hour.....lbs.	.....
30.	Weight of dry coal burned per hour per square foot of grate surface.....lbs.	.....
31.	Weight of coal burned per hour per square foot of heating surface.....lbs.	.....
32.	Weight of water evaporated per hour.....lbs.	.....
33.	Equivalent weight of water evaporated per hour with feed-water at 100° and pressure at 70 lbs.....lbs.	.....
34.	Equivalent weight of water from 100° at 70 lbs. evaporated per square foot of heating surface.....lbs.	.....

Principal Results, Complete Engine and Boiler.

35.	Coal consumed per I. H. P. per hour.....lbs.	.....
36.	Coal consumed per dynamometer horse-power per hour .....lbs.	.....
37.	Weight of "standard coal" consumed per I. H. P. per hour .....lbs.	.....
38.	Weight of "standard coal" consumed for a dynamometer horse-power per hour.....lbs.	.....

Boiler Results.

39.	Water evaporated per pound of coal.....lbs.	.....
40.	Equivalent evaporation per pound of coal from and at 212°.....lbs.	.....
41.	Equivalent evaporation per pound of combustible from and at 212°.....lbs.	.....
42.	Heat imparted to each pound of steam used from average temperature of feed at average steam pressure in British thermal units.....	.....

Cylinder Data.

43.	Mean initial pressure above atmosphere.....lbs.		.....
		H. P. Cyl.	L. P. Cyl.
44.	Cut-off pressure above zero.....lbs.	.....	.....
45.	Release pressure above zero.....lbs.	.....	.....
46.	Compression pressure above zero.....lbs.	.....	.....

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		H. P. Cyl.	L. P. Cyl.
47.	Lowest back pressure above or below atmosphere .....lbs.	.....	.....
48.	Proportion of forward stroke completed at cut-off	.....	.....
49.	Proportion of forward stroke completed at release	.....	.....
50.	Proportion of return stroke uncompleted at compression	.....	.....

Cylinder Results.

		H. P. Cyl.	L. P. Cyl.
51.	Total water consumed per indicated horse-power per hour corrected for moisture in steam.....lbs.		
52.	Water consumed per I. H. P. per hour by cylinders alone (from line 51 less all measured losses).....lbs.		
53.	Steam accounted for by indicators at cut-off.lbs.	.....	.....
54.	Steam accounted for by indicators at release.lbs.	.....	.....
55.	Proportion of feed-water used by cylinders (line 52) accounted for at cut-off.....lbs.	.....	.....
56.	Proportion of feed-water used by cylinders accounted for at release .....lbs.	.....	.....
57.	Total heat supplied by boiler to cylinders per hour in British thermal units.....	.....	.....
58.	Total heat supplied by boiler to cylinders per minute per indicated horse-power in British thermal units.....	.....	.....
59.	Total heat supplied by boiler to cylinders per minute per dynamometer horse-power in British thermal units.....	.....	.....

Reports should give a copy of a set of sample indicator diagrams, also combined diagram (in case of compound engines) and a chart showing graphically the principal data.

SUPPLEMENT.

Description of Norfolk & Western Indicator Rigging. Fig. 1, General Arrangement. Fig. 2, Details.

This form of indicator rigging involves the use of a lever (supported from the running-board by a suitable bracket), and connected at its lower end to the cross-head (by a link 12 in. long). The indicator drum cord takes its motion from a square bar working in suitable guides and connected by a short link to the main lever. In order to secure a perfectly parallel motion, the length of the cross-head link should bear the same ratio to the length of the indicator-bar link as the full length of the main lever bears to the distance from fulcrum of main lever to point of connection of the indicator-bar link. For an engine with 24-inch stroke this ratio should be 1 to 6, in order to produce an indicator card 4 inches

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long, and the long and short links should be 12 inches and 2 inches, respectively.

Description of Valve Motion Indicator. Fig. 3.

In this apparatus a string is wound around the groove on one end of drum, and passed over proper pulleys until it leads off in a line with the motion of the cross-head, and the other end is attached to the cross-head, so that any motion of the piston is communicated by the cord to the drum, causing corresponding rotation.

A cord from the pen-bar is led over suitable pulleys and attached to valve rod in the same manner. The combination of the two motions, as will be seen, will give an elliptical diagram in which the abscissæ represent the position of the piston, and the ordinates the position of the valve.

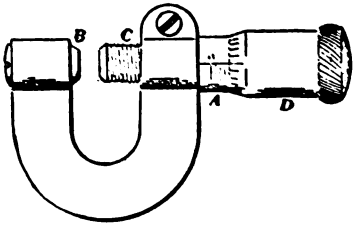
Description of Boiler Lever Indicator. Fig. 4.

This apparatus consists of a spirit level mounted in a saddle which slides on an arc of a large circle. This arc is graduated, and should be sufficiently curved to operate on the heaviest grade upon which the engine will be tested.

By putting the engine on jacks or cranes, and giving different elevations to the boiler, the height of water may be measured by means of a meter to certain points on the gauge-glass, and a corresponding table made, which will denote the quantity of water in the boiler for each different angular position of the boiler. These figures can be used to make corrections on the meter readings, allowing for inclinations of the track on which the engine is standing by simply pushing the spirit lever to a horizontal position and noting the reading on the indicator.

SHEET METAL GAUGE.

At the convention of 1882 the Brown & Sharpe micrometer gauge shown below was adopted as standard for the measurement of sheet metal (see page 132, report 1882). Reaffirmed 1891 (see pages 160, 161, report 1891).



DECIMAL GAUGE.

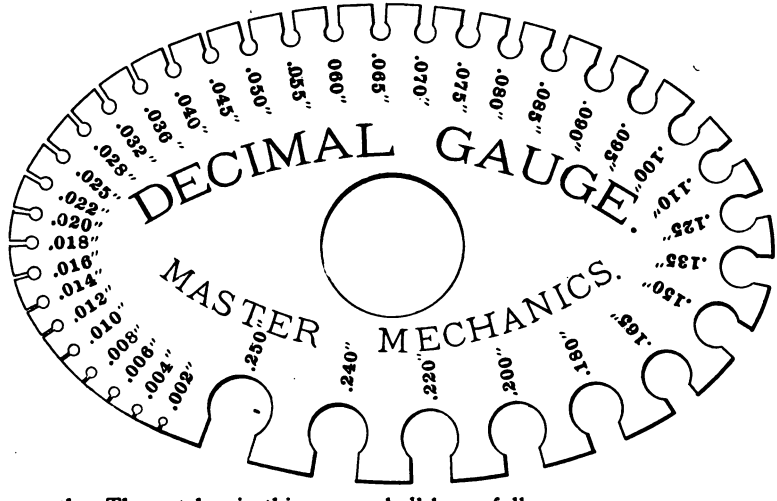
At the convention of 1895 the following was adopted as a standard Decimal Gauge:

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1st. The micrometer caliper should be used for laboratory and tool-room work, and in the shop when specially desired.

2d. The solid notch gauge should be used for general shop purposes.

3d. The form of this gauge shall be an ellipse whose major axis is 4 inches, the minor axis 2.5 inches, and the thickness .1 inch, with a central hole .75 inch in diameter.



4th. The notches in this gauge shall be as follows:

.002″	.022″	.060″	.110″
.004″	.025″	.065″	.125″
.006″	.028″	.070″	.135″
.008″	.032″	.075″	.150″
.010″	.036″	.080″	.165″
.012″	.040″	.085″	.180″
.014″	.045″	.090″	.200″
.016″	.050″	.095″	.220″
.018″	.055″	.100″	.240″
.020″	.....	.....	.250″

5th. All notches to be marked as in the above list.

6th. The gauge must be plainly stamped with the words "Decimal Gauge" in capital letters .2 inch high, and below this the words "Master Mechanics."

7th. In ordering material, the term gauge shall *not* be used, but the thickness ordered by writing the decimal as in above list. For sizes over ¼ inch, the ordinary common fractions may be used.

STANDARD DIMENSIONS AND THREADS OF WROUGHT PIPE.

At the convention of 1899, what is known as the Briggs Standard, as determined by the Pratt & Whitney gauges, of threads for wrought-iron pipe and couplings, was adopted as a standard of the Association.

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The gauges used by the Pratt & Whitney Company were made by them from an autograph copy of a table made by Mr. Robert Briggs personally, who originally established and published these standard threads.

In 1908 these dimensions were revised and 11-inch and 12-inch pipe included. The words "wrought pipe" in the above heading includes wrought iron and steel pipe.

Diameter of Tube.			Thickness of metal.	Screwed Ends.	
Nominal inside.	Actual inside.	Actual outside.		Number of threads per inch.	Length of perfect screw.
Inches.	Inches.	Inches.	Inch.	No.	Inch.
⅛	.269	0.405	0.068	27	0.19
¼	.364	0.540	0.088	18	0.29
⅜	.493	0.675	0.091	18	0.30
½	.622	0.840	0.109	14	0.39
¾	.824	1.050	0.113	14	0.40
1	1.047	1.315	0.134	11½	0.51
1¼	1.380	1.660	0.140	11½	0.54
1½	1.610	1.900	0.145	11½	0.55
2	2.067	2.375	0.154	11½	0.58
2½	2.467	2.875	0.204	8	0.89
3	3.066	3.500	0.217	8	0.95
3½	3.548	4.000	0.226	8	1.00
4	4.026	4.500	0.237	8	1.05
4½	4.508	5.000	0.246	8	1.10
5	5.045	5.563	0.259	8	1.16
6	6.065	6.625	0.280	8	1.26
7	7.023	7.625	0.301	8	1.36
8	7.981	8.625	0.322	8	1.46
9	8.937	9.625	0.344	8	1.57
10	10.018	10.750	0.366	8	1.68
11	11.000	11.750	0.375	8	1.79
12	12.000	12.750	0.375	8	1.90

Tapers of conical tube ends, 1 in 32 to axis of tube. (¾-inch per foot.)

By the late action of the Manufacturers of Wrought-Iron Pipe, 9-inch outside diameter has been excepted from the original list, as above noted, the diameter now adopted being 9.625 instead of 9.688 inches given in the Briggs table.

STANDARD PIPE UNIONS.

At the convention of 1902 standard dimensions for pipe unions ⅛ to 4 inches, inclusive, were proposed for adoption, and, at the convention of 1903, the same were adopted as standard. These dimensions are shown on Table A.

AXLES FOR LOCOMOTIVE TENDERS.

At the convention of 1879 the Master Car Builders' Standard Axle with 3¾ by 7 inch journals was adopted as standard. (See pages 14-35, 52-58, report 1879.) Changed to Recommendations 1891. (See pages

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160, 161, report 1891.) Modified to conform to M. C. B. standard 1903. See plate 1.

At the convention of 1890 the Master Car Builders' standard axle with journals 4¼ by 8 inches was adopted as standard. See page 166, report 1890.) Changed to Recommendations in 1891. (See pages 160, 161, report 1891.) Modified to conform to M. C. B. standard in 1903. See plate 1.

At the convention of 1903 the Master Car Builders' standard axle with 5 by 9 inch journals was adopted as standard. See report of Committee on Revision of Standards, 1903. See plate 1.

At the convention of 1903 the Master Car Builders' standard axle with journals 5½ by 10 inches was made a standard. See report of Committee on Revision of Standards. See also plate 1.

In 1908 these standard axles were made to conform to the M. C. B. standard, and as revised are shown on Sheet M. M. 1. Also the text of tests as prescribed by the M. C. B. Association was adopted as standard, as follows:

SPECIFICATIONS FOR IRON AXLES.

Car axles for the use of this company will be ordered subject to the following conditions:

1. All axles must conform in shape and size to the dimensions shown on the blue-prints, which will be furnished by the.....R. R. Co.

2. All axles must be cut off and faced to exact lengths, and be centered with 60 degree centers in the manner indicated in blue-prints, so as to prevent lathe centers from bottoming. Axles must be made of double-work fagoted scrap, 16 per cent of new bar iron worked into the center of the axles being allowed if desired. Axles must be well hammered and free from any clearly defined open seams. They must finish in the lathe with journal free from flaws in the shape of holes, pieces shelled out, or open seams large enough, so that with a knife-blade scale or dirt can be removed from such seams, or open seams showing a clear opening of 1-32 inch or over, and being more than 1 inch long. The maker's name or initials must be stamped plainly on each axle.

3. All axles are to be inspected and tested at the works where they are made. The.....shall be notified when they are ready for inspection. Under no circumstances shall car axles be shipped from the works where they are made until they have been tested, inspected and accepted by a proper representative of the company.

4. For each one hundred axles or fraction thereof ordered, one additional axle must be furnished for test. This axle will be selected at random from the pile, and subjected to the prescribed drop test for iron axles of its class. It it stands the test the one hundred axles, or fractional part thereof that it represents, will be inspected, and only those accepted that are made in a workmanlike manner and are free from defects mentioned in these specifications. All axles received are subject to rejection if they do not finish in the lathe in accordance with the

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requirements herein given. The manufacturer must furnish, free of charge, the axles that are to be tested, the testing apparatus, and the assistance necessary to enable the inspector to make a satisfactory inspection and test. Axles will not be accepted if the diameters fall below the dimensions for forged sizes given in the blue-prints, or if exceeding those dimensions by more than ⅛ inch. Car axles in the rough must not have less than the prescribed minimum weight, nor more than the prescribed maximum weight for axles of their class.

AXLE DROP TEST.

5. All axles will be tested physically by drop test. The testing machine must conform in its essential parts to the drawings adopted by the Master Car Builders' Association. These essential parts are: The points of supports on which the axle rests during tests must be three (3) feet apart from center to center; the tup must weigh 1,640 pounds; the anvil, which is supported on springs, must weigh 17,500 pounds; it must be free to move in a vertical direction; the springs upon which it rests must be twelve in number, of the kind described on drawing, and the radius of the supports and of the striking face on the tup in the direction of the axis of the axle must be five (5) inches. When an axle is tested it must be so placed in the machine that the tup will strike it midway between the ends, and it must be turned over after the first and third blows, and when required after the fifth blow. After the first blow the deflection of the axle under test will be measured in the manner specified below.

6. It is desired that the axles when tested as specified above shall stand the number of blows at the heights specified in the following table without rupture, and without exceeding, as the result of the first blow, the deflections given:

Axle.	No. Blows.	Height of Drop.	Deflection.
M. C. B. 4¼ by 8 inch journals.....	5	12½ ft.	7⅛ ft.
M. C. B. 5 by 9 inch journals.....	5	29 ft.	6 1/16 ft.
M. C. B. 5½ by 10 inch journals.....	5	36 ft.	5 7/16 ft.

7. Axles will be considered as having failed on drop test and will be rejected if they rupture or fracture in any way, or if the deflection resulting from the first blow exceeds the following:

M. C. B. axle, 4¼ by 8 inch journals.....8 1-8 inches.
M. C. B. axle, 5 by 9 inch journals.....8 1-16 inches.
M. C. B. axle, 5½ by 10 inch journals.....6 1-16 inches.

In order to measure the deflection, prepare a straight-edge as long as the axle by reinforcing it on one side, equally at each end, so that when it

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is laid on the axles the reinforced parts will rest on the collars of the axle, and the balance of the straight-edge not touch the axle at any place. Next place the axle in position for test, lay the straight-edge on it, and measure the distance from the straight-edge to the axle at the middle point of the latter. Then, after the first blow, place the straight-edge on the now bent axle in the same manner as before, and measure the distance from it to that side of the axle next to the straight-edge at the point farthest away from the latter. The difference of the two measurements is the deflection.

SPECIFICATIONS FOR STEEL AXLES.

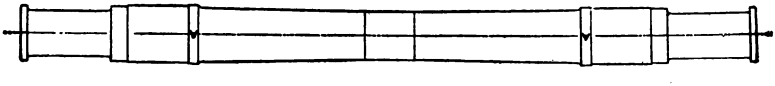
1. Axles will be ordered not less than 100 on one order. All axles must be made and finished in a workmanlike manner, and must be free from cracks, or seams, or flaws which can be detected by the eye. All parts must be rough turned, except at point "A" on diagram below.

2. All axles must be made of steel, and the material desired have the following composition:

Carbon	0.40 per cent.
Manganese, not above	0.50 per cent.
Silicon	0.05 per cent.
Phosphorus, not above	0.05 per cent.
Sulphur, not above	0.04 per cent.

3. All axles must conform in sizes, shapes and limiting weights to the requirements given on the order or print sent with it. The rough turning must be done with a tool so shaped as to leave the surface free from ridges; and in centering them 60-degree centers must be used with proper clearance for lathe centers. All axles must be legibly stamped when offered for test, on the unfinished portion, "A" on diagram below, with the blow or heat number and the date. and on the cylindrical portion at center they must be stamped with the name of the maker.

Portions marked "A" to be unfinished and to have stamped upon either of them below number and date.



4. Manufacturers must notify..... when they are ready to ship not less than 100 axles; must have all the axles made from each heat, and no others, in a pile by themselves; must furnish the testing machine referred to in Section 6, and the proper appliances for checking the dimensions and weights; must have a car or cars ready to receive shipment; must furnish the labor and power neces-

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sary to enable the inspector to promptly inspect and test; and ship or store the axles when tests are finished. Axles which, when offered for test, are so rusty as to hide defects will not be considered.

5. A shipment of axles being ready for test, the inspector will first make a list of the heat numbers in the various piles of axles offered, and the number of axles bearing the same heat number in each pile. If he finds in any pile axles bearing different heat numbers he must, before going further, have the pile rearranged, so that only those axles having the same heat number will be in the same pile. Also, if he finds in any pile any axles having evidence of changed or defaced heat numbers, or any axles having heat numbers not clearly legible, or any bearing heat numbers previously rejected, he will exclude such axles from further consideration. He will then examine the axles in each pile or heat, as to workmanship and defects visible to the eye, and as to whether they conform to dimensions and directions on the order, or tracing, or in these specifications. All axles not satisfactory in these respects must be laid aside and will not be further considered. This being done, if less than thirty axles in any heat are left, he will refuse to consider that heat further. If in this inspection defects are found which the manufacturer can remedy while the inspector is at the works, he may allow such defects to be cured and may count the axles which are successfully treated in this way as a part of the thirty above mentioned. Not less than thirty axles from any one heat having passed the foregoing inspection, the inspector will select from each pile or heat, one axle at random, and subject it to the physical test prescribed for such axles as may be under consideration. If the test axle fails to fill the physical requirements, all the axles from that heat of steel will be regarded as rejected, and none of them will at any time be considered again. If the test axle passes physical test, the inspector will draw a straight line parallel with the axis of this test axle ten (10) inches long, starting from one end of it, and prick-punch this line at several points. He will then have a piece about six (6) inches long cut off from the same axle, so as to leave some of the prick-punch marks on each piece of the axle. The 6-inch piece must be sent at once, properly tagged, to..... The piles of axles which have passed physical test will be allowed to remain as the inspector leaves them, until the results of the chemical test are known. The 6-inch piece being received at the laboratory, a line will be drawn from the prick-punch line above described, through the center of the axle across the cut-off end, and a prick-punch mark made on this last line, 40 per cent of the distance from the center to the circumference of the axle. Borings for analysis will be taken by means of a $\frac{5}{8}$-inch diameter drill, acting parallel to the axis of the axle, and starting with its center in the last described prick-punch mark. The borings will be analyzed in accordance with standard methods, and the results of analysis will be communicated to the inspector, who will at once proceed to the works, and reject, or accept and ship, or mark and store, as the case may be, the axles in question.

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If the analysis of any test axle shows that the steel does not meet the chemical requirements, all of the axles of that heat will be regarded as rejected, and none of them will at any time be considered again. If the analysis of any test axle shows that the steel meets the chemical requirements, all of the axles of that heat which have passed inspection and physical test will be regarded as accepted. The inspector will proceed to load and ship from the accepted axles as many as may be required to fill the order. If, as the result of inspection and the physical and chemical tests, more axles are accepted than the order calls for, such accepted axles in excess will be stamped by the inspector with his own name, and will then be piled and allowed to remain at the works, subject to further orders from the purchasing agent. On receipt of further orders, axles once accepted will, of course, not be subject to further test, but in no case will even accepted axles be loaded and shipped except in the presence of the inspector. In all cases the inspector will keep an accurate record of the heat numbers, of the number of axles in each heat which are rejected, or stored, and will transmit this information with each report.

6. All axles will be tested physically by drop test. The testing machine must conform in its essential parts to the drawings adopted by the Master Car Builders' Association. These essential parts are: The points of supports on which the axle rests during tests must be three feet apart from center to center; the tup must weigh 1,640 pounds; the anvil, which is supported on springs, must weigh 17,500 pounds; it must be free to move in a vertical direction; the springs upon which it rests must be twelve in number, of the kind described on drawing; and the radius of supports and of the striking face on the tup in the direction of the axis of the axle must be five (5) inches. When an axle is tested it must be so placed in the machine that the tup will strike it midway between the ends, and it must be turned over after the first and third blows, and when required, after the fifth blow. After the first blow, the deflection of the axle under test will be measured in the manner specified below.

7. It is desired that the axles, when tested under the drop test as specified above, shall stand the number of blows at the height specified in the following table without rupture and without exceeding as the result of the first blow the deflections given:

Axle.	No. Blows.	Height of Drop.	Deflection.
M. C. B. 4¼ by 8 inch journals for 60,000-pound cars.....	5	34 feet	7 inches
M. C. B. 5 by 9 inch journals for 80,000-pound cars.....	5	43 "	5¼ "
M. C. B. 5½ by 10 inch journals for 100,000-pound cars	7	43 "	4 "

8. Axles will be considered as having failed on physical test and will be rejected if they rupture or fracture in any way, or if the deflection resulting from the first blow exceeds the following:

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M. C. B. axle, 4¼ by 8 inch journals.....7½ inches.
M. C. B. axle, 5 by 9 inch journals.....6¼ inches.
M. C. B. axle, 5½ by 10 inch journals.....4½ inches.

9. Axles will be considered to have failed on chemical test and will be rejected if the analysis of the borings taken as above described gives figures for the various constituents below, outside the following limits, namely:

Carbon.....below 0.35 per cent, or above 0.50 per cent.
Manganese .....above 0.60 per cent.
Phosphorus .....above 0.07 per cent.

In order to measure the deflection, prepare a straight-edge as long as the axle, by reinforcing it on one side, equally at each end, so that when it is laid on the axle, the reinforced parts will rest on the collars of the axle, and the balance of the straight-edge not touch the axle at any place. Next place the axle in position for test, lay the straight-edge on it and measure the distance from the straight-edge to the axle at the middle point of the latter. Then, after the first blow, place the straight-edge on the now bent axle in the same manner as before, and measure the distance from it to that side of the axle next to the straight-edge at the point farthest away from the latter. The difference in the two measurements is the deflection.

JOURNAL BOX, BEARING AND PEDESTAL.

At the convention of 1903 the M. C. B. journal boxes and contained parts for the 3¾ by 7 inch, 4¼ by 8 inch, 5 by 9 inch and 5½ by 10 inch standard axles, as shown on plate 1, were made a standard of the Association. They are shown on Sheets M. M. 2 to 13, inclusive. Revised 1908.

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RECOMMENDATIONS.

At the convention in 1872 the following recommendations were adopted:

"In the matter of cost of keeping up the repairs of engines engaged in switching service exclusively, that an allowance of six miles per hour for the time that such engines are in actual use be allowed:

"That for engines running local freight trains an allowance of six per cent to the train mileage be added for switching:

"That where engines run empty to exceed one-half mile between where the trains are taken or left and the roundhouse, such mileage should be computed, and that for engines running through freight or passenger trains no computation should be made for switching:

AIR BRAKE AND SIGNAL INSTRUCTIONS.

At the convention of 1892 a code of Air Brake and Signal Instructions was adopted as Recommendation of the Association. Some modifications were made in 1898, and the modified rules are shown on pages 205-228, report 1898. Revised, June, 1904, as follows:

The title of the revised instructions should be,

"AIR BRAKE AND TRAIN AIR SIGNAL INSTRUCTIONS."

A.—GENERAL INSTRUCTIONS.

1. The following rules and instructions are issued for the government of all employes of this railroad whose duties bring them in contact with the maintenance or operation of the air brake and train air signal. They must be obeyed in all respects, as employes will be held responsible for the observance of same as strictly as for the performance of any other duty.

Every employe whose duties are connected in any way with the operation of the air brake will be examined from time to time as to his qualifications for such duties by the Inspector of Air Brakes or other person appointed by the proper authority, and a record will be kept of such examination.

A book of information will be issued, in convenient form, giving a complete explanation of such parts of the air brake and train air signal equipment as is deemed necessary for the care and operation of same. Any employe of this railroad whose duties require a knowledge of the operation and maintenance of the air brake and air signal will be furnished

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with a copy of same upon application at place designated by special notice, and every employe will be held responsible for a full knowledge of his duties in the operation or maintenance of the air brake or signal equipment.

B.—INSTRUCTIONS TO ENGINEMEN.

Enginemen when taking charge of locomotives must see that the air brake apparatus on engine and tender is in good working order, and that the air pump and lubricator work properly; that the devices used for regulating main reservoir and train pipe pressures are adjusted at the authorized amount; that brake valve works properly in all its positions; and that, when brakes are fully applied, with cam type of driver brake the pistons do not travel less than 2 inches nor more than 3½ inches, and with other forms from 4 inches to 6 inches, and that the tender brake piston does not travel less than 6 inches nor more than 9 inches. They must know that the air signal responds by opening hose cock on its train pipe.

Enginemen must report to roundhouse foremen, in writing, at the end of the run, any defects in the air brake or train air signal apparatus.

MAKING UP TRAINS, TESTING BRAKES AT TERMINAL POINTS AND BEFORE STARTING DOWN SUCH GRADES AS MAY BE DESIGNATED BY SPECIAL INSTRUCTIONS.— The train pipe under the tender must always be blown out and maximum pressure obtained in main reservoir before coupling engine to train.

After the train has been charged with air pressure, the engineman shall, at the request of the inspector or trainmen, apply the brakes with full service application and leave them so applied until all brakes operated from the engine have been inspected and the signal given to release. The engineman must then release the brakes and must not leave the station until it has been ascertained that all brakes are released and he has been informed by the inspector, or trainmen, of the number of brakes in service and their condition. In testing passenger brakes, the American Railway Association code of train air signals for applying or releasing must be used, one of which signals must be given from the discharge valve on rear car.

Following the separation of couplings for local switching, or when engine or train has been parted for any purpose, the above test need not be complied with further than to ascertain, by test, that the rear brakes are responsive to brake valve on engine and that all brakes have properly released. However, when cars are added to train, the brakes on such cars must be inspected as in terminal test. When a passenger train back-up hose is to be used to control the train, the brakes must be applied for test with the back-up hose, and released from the brake valve on the locomotive.

4. SERVICE APPLICATION.— In applying the brakes to steady the train

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on descending grades, or for reducing speed for any purpose, an initial train pipe reduction of not less than five pounds must be made. Releasing brakes at low speeds must be performed with great care, dependent upon local conditions.

With freight trains, first allow the slack to run up against the locomotive. Great care must then be taken to apply the brakes with five to nine pounds reduction, according to length of train pipe, and not make a second reduction until the effect of the first reduction is felt on entire train, in order to prevent shocks which otherwise might be serious. When a freight train must be brought to a full stop, the train brakes must be held applied until stop is made.

In making a service stop with a passenger train, ALWAYS RELEASE THE BRAKES A SHORT DISTANCE BEFORE COMING TO A DEAD STOP, except on heavy grades, to prevent shocks at the instant of stopping. Even on moderate grades it is best to do this, and then, after release, to apply the brakes lightly, to prevent the train starting, so that when ready to start the release will take place quickly.

5. EMERGENCY APPLICATIONS.— The emergency application of the brakes must not be used, except in actual emergencies. Under such conditions the brake valve must be left in emergency position until train has come to a full stop.

ENGINEMAN'S STRAIGHT AIR BRAKE VALVE ON LOCOMOTIVES.

a — Always keep both brakes cut in and ready for operation, unless failure of some part requires cutting out.

b — Always carry an excess pressure of ten pounds, or more, in the main reservoir, as this is necessary to insure a uniformly satisfactory operation.

c — When using the automatic brake, keep the straight air brake valve in release position; and when using straight air, keep the automatic brake valve in running position; this to avoid driver and tender brakes sticking.

d — The straight air reducing valve should be kept adjusted at forty-five pounds, and the driver and tender brake safety valves at fifty-three pounds.

With freight trains, first allow the slack to run up against the loco- valves to operate, it indicates that same are out of order, or too high adjustment of the reducing valve or too low adjustment of the safety valve, or leakage of same. Have them tested and adjusted.

6. BRAKES APPLIED FROM AN UNKNOWN CAUSE.— If it is found that the train is dragging as though the brakes were applied, without rapid falling of the train line pointer, the engineman must make an effort to release the brakes, which may be done as follows: First, if train pipe pressure is less than the authorized amount and the required excess pressure is

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carried in the main reservoir, move the handle of the brake valve to the full release position for a few seconds and then return it to the running position; secondly, should the train pipe be fully charged with pressure, apply the brakes with a five or ten pounds reduction, according to the length of the train pipe, and release the brakes in the usual manner. In case the brakes can not be released, the train must be stopped and the trainmen notified to examine the brakes.

If, however, the brakes go on suddenly with a fall of the train line pointer, it is evidence that (a) a conductor's valve has been opened, (b) a hose has burst or other serious leak has occurred, or (c) the train has parted. In such an event, the locomotive throttle should be closed and the brake valve handle immediately placed on lap or emergency position, to prevent the escape of air from the main reservoir, and left there until the train has stopped and the brake apparatus has been examined and the signal to release given.

7. Braking by Hand.— Never Use the Air Brake when it is known that the trainmen are operating the brakes of the air brake cars by hand, except in cases of emergency, as there is danger of injury to the trainmen by so doing.

8. Cutting Out Brakes.— The Driver and Tender Brakes Must Always be Used Automatically at Every Application of the Train Brake, unless defective, except upon such grades as shall be designated by special instructions.

When necessary to cut out either driver or tender brake, on account of defects, it shall be done by turning the handle of the four-way cock in the triple valve down to a position midway between a horizontal and a vertical position, first releasing the brake and leaving the bleed cock open. With the special types of triple valve, close the cut-out cock in the branch pipe.

9. Double Headers.— When two or more locomotives are coupled in the same train, the brakes must be connected through to and operated from the head engine. For this purpose a cock is placed in the train pipe, just below the brake valve. Engineman of each locomotive except the head one must close this cock and carry the handle of brake valve in running position. He will start his air pump and let it run, as though he were going to use the brake, for the purpose of maintaining air pressure on his locomotive and enabling him to assume charge of the train brakes should occasion require it.

10. An Extra Air-Brake Hose, Complete, must always be carried on the locomotive, for repairs in case of burst hose. Upon locomotives having the air signal, a signal hose, complete, must also be carried for the same purpose.

C.— INSTRUCTIONS TO TRAINMEN.

11. Making up Trains and Testing Air Brakes.— When the locomotive has been coupled to the train, or when two sections have been

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coupled together, the brake and signal couplings must be united, the cocks in the train pipes — both brake and signal — must all be open, except those at the rear end of the last car, which must be closed, and the hose hung up properly in the dummy coupling, when cars are so equipped.

After the train has been charged with air, the engineman must then be requested to apply the brakes. When he has done so, the brakes of each car must be examined to see if they are properly applied. When it is ascertained that each brake is applied, the engineman must be signaled to release the brakes. (In testing passenger brakes the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.) The brakes of each car must then be examined to see that each is released, and the engineman informed as to the number of brakes in service and their condition.

If any defect is discovered it must be remedied and the brakes tested again — the operation being repeated until it is ascertained that everything is right. The conductor and engineman must then be notified that the brakes are all right. Following the separation of couplings for local switching, or when engine or train has been parted for any purpose, the above test need not be complied with other than to ascertain, by test, that the rear brakes are responsive to brake valve on engine and that all brakes have properly released. At points where there are no inspectors, trainmen must carry out these instructions. No passenger train must be started out from an inspection point with the brakes upon any car cut out or in a defective condition, without special orders from the proper officers. The air brakes must not be alone relied upon to control any freight train with a smaller proportion of cars with the air brake in service than provided for by special instructions. When hand brakes are also used they must be applied upon those cars next behind the air-braked cars, except in cases of emergency.

12. Detaching Locomotive or Cars.— First close the cocks in the train pipes at the point of separation, and then part the couplings, invariably by hand.

13. Couplings Frozen.— If the couplings are found to be frozen together or covered with an accumulation of ice, the ice must first be removed and then the couplings thawed out by a torch to prevent injury to the gaskets.

14. Brakes Sticking.— If brakes are found sticking, the signal "brakes sticking" must be given as hereafter prescribed by the American Railway Association, or by special rules, in which case, if the brakes can not be released from the locomotive, or if the brakes are applied to detached cars, the release may be effected by opening the bleed cock in the auxiliary reservoir until the air begins to release through the triple valve, when the reservoir cock must immediately be closed.

15. Train Breaking Into Two or More Parts.— First close the

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cock in the train pipe at the rear of the first section and signal the engineman to release the brakes. Having coupled to the second section, observe the rule for making up trains — first being sure that the cock in the train pipe at the rear of second section has been closed, if the train has broken into more than two sections. When the engineman has released the brakes on the second section, the same method must be employed with reference to the third section, and so on. When the train has been once more entirely united, the brakes must be inspected on each car to see that all are released before proceeding.

16. CUTTING OUT THE BRAKE ON A CAR.— If, through any defect of the brake apparatus, it becomes necessary to cut out the brake upon any car, it may be done by closing the cock in the cross-over pipe near the center of the car where the quick-action brake is used, or by turning the handle of the cock in the triple valve to a position midway between a horizontal and a vertical, where the plain automatic brake is used, first releasing the brake. With the special types of triple valves, close the cut-out cock in the branch pipe. When the brake has been thus cut out, the cock in the auxiliary reservoir must be opened and left open upon passenger cars, or held open until all the air has escaped from the reservoir upon freight cars. THE BRAKE MUST NEVER BE CUT OUT UPON ANY CAR UNLESS THE APPARATUS IS DEFECTIVE, and when it is necessary to cut out a brake the conductor must notify the engineman and also send in a report stating the reason for so doing.

17. CONDUCTOR'S VALVE.— Should it become necessary to apply the brakes from the train, it may be done by opening the conductor's valve placed in each car so equipped. THE VALVE MUST BE HELD OPEN UNTIL THE TRAIN COMES TO A FULL STOP, AND THEN MUST BE CLOSED AGAIN.

This method of stopping the train must not be used except in case of emergency.

18. BURST HOSE.— In the event of the bursting of a brake hose, it must be replaced and the brakes tested before proceeding, provided the train be in a safe place. If it is not, the train pipe cock immediately in front of the burst hose must be closed, and the engineman signaled to release. All the brakes to the rear of the burst hose must then be released by hand, and the train must then proceed to a safe place where the burst hose must be replaced and the brakes again connected and tested, so as to ascertain that the rear brakes are responsive, by test, to the brake valve on engine. One extra air brake hose complete should be carried by all crews and one extra signal hose complete carried by passenger crews for repairs.

19. BRAKES NOT IN USE.— When the air brakes are not in use, either upon the road or in switching, the hose must be kept coupled between the cars or hung up properly to the dummy couplings, when cars are so equipped.

20. PRESSURE-RETAINING VALVE.— When this valve is to be used,

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the trainmen must, at the top of the grade, test the brakes upon the whole train, and must then pass over the train and turn the handles of the pressure-retaining valves horizontally upon all or a part of the cars, as may be directed. At the foot of the grade, the handles must all be turned downward again. Special instructions will be issued as to the grades upon which these valves are to be used.

21. TRAIN AIR SIGNAL.— In making up trains, all couplings and car discharge valves on the cars must be examined to see if they are tight. Should the car discharge valve upon any car be found to be defective, it may be cut out of use upon that car by closing the cock in the branch pipe leading to the valve. The conductor must always be immediately notified when the signal has been cut out upon any car, and he must report the same for repairs.

In using the signal, pull directly down upon the cord during one full second for each intended blast of the signal whistle, and allow three seconds to elapse between the pulls.

22. REPORTING DEFECTS TO INSPECTORS.— Any defect in either the air brake or air signal apparatus discovered must be reported to the inspector at the end of the run; or, if the defect be a serious one in passenger service, it must be reported to the nearest inspector, and it must be remedied before the car is again placed in service.

D.— INSTRUCTIONS TO ENGINE-HOUSE FOREMEN.

23. GENERAL.— It is the duty of the engine-house foremen to see that the air brake and signal equipment is properly inspected upon each locomotive after each run. It must be ascertained that all pipe joints, connections and all other parts of the apparatus are air tight, duplex gauges tested every thirty days, and that the apparatus is in good working order.

24. AIR PUMP.— The air pump must be tested under pressure, and if found to be working imperfectly in any respect, it must be put into thoroughly serviceable condition.

25. PUMP GOVERNOR.— The pump governor should cut off the steam supply to the pump when authorized pressure has been obtained.

26. BRAKE VALVE.— This valve must be kept clean and known to be in working order in all its positions, before the locomotive leaves the engine-house.

27. ADJUSTMENT OF BRAKES.— The driver brakes must be so adjusted that the piston travel on the cam type will be not less than 2 inches nor more than 3½ inches, and in other forms not less than 4 inches nor more than 6 inches. When the cam brake is used care must be taken to adjust both cams alike, so that the point of contact of the cams shall be in line with the piston rod. The tender brake must be adjusted by means of the dead truck levers, so that the piston travels not less than

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six inches when the air brake is applied and the hand brake is released. This adjustment must be made whenever the piston travel is found to exceed nine inches.

28. BRAKE CYLINDERS AND TRIPLE VALVES.— These must be examined, cleaned and lubricated at least once every six months. A record must be kept of the dates of last cleaning and lubrication of these parts for each locomotive.

29. DRAINING.— The main reservoir, and also the drain cup in the train pipe under the tender, must be drained of any accumulation after each trip. The auxiliary reservoirs and triple valves must also be drained frequently, and daily in cold weather, and the train pipe under the engine and tender blown out.

30. AIR SIGNAL.— The train air signal apparatus must be examined and tested by suitable appliances from both the head of the engine and the rear of the tender, to know that the whistle responds properly. A pressure gauge must be applied to the air signal pipe once each month, and oftener if found to be necessary, to ascertain that the reducing valve maintains the authorized pressure per square inch in the train signal pipe.

E.— INSTRUCTIONS TO INSPECTORS.

31. GENERAL.— It is the duty of all inspectors to see that the couplings, the pipe joints, the triple valves, the high speed reducing valve, the conductor's valves, the air signal valves, and all other parts of the brake and signal apparatus are in good order, of standard size for the car and free from leaks. For this purpose they must be tested under the full air pressure as used in service. No passenger train must be allowed to leave a terminal station with the brake upon any car cut out, or in a defective condition, without special orders from the proper officer.

If a defect is discovered in the brake apparatus of a freight car, which can not be held long enough to give time to correct such defect, the brake must be cut out and the car properly carded, to call the attention of the next inspector to the repairs required.

Special rules will specify the smallest proportion of freight cars, with the air brakes in good condition, which may be used in operating the train as an air brake train.

32. MAKING UP TRAINS AND TESTING BRAKES.— In making up trains, the couplings must be united and the cocks at the ends of the cars all opened, except at the rear end of the last car, where the cocks must be closed; the inspector must know that the air is passing through the pipes to the rear end, and the couplings properly hung up to the dummy couplings if so equipped. After the train is fully charged the engineman must be requested to apply the brakes. When the brakes have been applied, they must be examined upon each car to see that they are applied with proper piston travel. This having been ascertained, the inspector

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must signal the engineman to release the brakes. (In testing passenger brakes the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.) He must then again examine the brakes upon each car to note that all have released. If any defect is discovered, it must be corrected and the testing of the brakes repeated, until they are found to work properly. The inspector must then inform both the engineman and conductor of the number of cars with brakes in good order.

This examination must be repeated if any change is made in the make-up of the train before starting.

HIGH SPEED REDUCING VALVES ON LOCOMOTIVES AND TENDERS must be tested at least once every month, and adjusted to authorized pressure, if necessary, and cleaned and lubricated at least once in three months, and oftener if tests show that same is necessary.

33. CLEANING CYLINDERS AND TRIPLE VALVES.— The brake cylinders and triple valves must be kept clean and free from gum. They must be cleaned and lubricated as often as once in six months upon passenger cars, and once in twelve months upon freight cars. The dates of the last cleaning and lubrication must be marked with white paint on the cylinder or reservoir, in the space left opposite the words:

Cylinder, cleaned and lubricated.....
Triple, cleaned and lubricated.....

The triple valves and auxiliary reservoirs must be frequently drained, especially in cold weather, by removing the plug in the bottom of the triple valve and opening the bleed cock in the reservoir.

34. GRADUATING SPRINGS.— The graduating springs in the Westinghouse quick-action freight triple valves are .049 inch in diameter, nickeled-steel wire, 16 coils, 2¾ inches free height, 29-64 inch inside diameter, and in passenger .08 inch diameter, nickeled steel wire, 13¼ coils, 2⅝ inches free height, 29-64 inch inside diameter. The graduating springs used in the Westinghouse plain triple valve in locomotive service are made of phosphor-bronze wire, .083 inch in diameter, 12 coils, 2½ inches free height, 25-64 inch inside diameter.

35. ADJUSTMENT OF BRAKES.— The slack of the brake shoes must be taken up by means of the dead truck levers.

In taking up such slack it must be first ascertained that the hand brakes are off, and the slack is all taken out of the upper connections, so that the truck levers do not go back within one inch of the truck timber or other stop, when the piston of the brake cylinder is fully back at the release position. When under a full application the brake piston travel is found to exceed nine inches upon passenger or freight cars, the brake shoe slack must be taken up and the adjustment so made that the piston shall travel not less than six inches. In taking up the brake shoe slack it must never be taken up by hand brakes. Where automatic slack

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adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere.

36. BRAKING POWER.— Where the cylinder lever has more than one hole at the outer end the different holes are for use upon cars of different weights.

It must be carefully ascertained that the rods are connected to the proper holes, so that the correct braking power shall be exerted upon each car.

37. REPAIR PARTS.— Inspectors must keep constantly on hand for repairs a supply of all parts of the brake and signal equipment that are liable to get out of order.

38. HANGING UP HOSE.— Inspectors must see that, when cars are being switched or standing in the yard, the hose is coupled between the cars or properly secured in the dummy couplings, when cars are so equipped.

39. RESPONSIBILITY OF INSPECTORS.— Inspectors will be held strictly responsible for the good condition of all the brake and signal apparatus upon cars placed in trains at their stations; they will also make any examination of brake apparatus or repairs to the same which they may be called upon to do by trainmen.

GENERAL QUESTIONS REGARDING THE USE OF THE AIR BRAKE AND TRAIN AIR SIGNAL.

GENERAL.

(All parties who have to do with the use, adjustment, care or repairs of air brakes should be thoroughly examined on these questions, in addition to the special questions for each class of men following them.)

1. Question. What is an air brake?

Answer. It is a brake applied by compressed air.

2. Q. How is the air compressed?

A. By an air pump on the locomotive.

3. Q. How does the compressed air apply the brakes?

A. It is admitted into a brake cylinder on each car, and it pushes out a piston in that cylinder, which pulls the brake on.

4. Q. How does the piston get back when the brakes are released?

A. There is a spring around the piston rod which is compressed when the brakes are applied, and when the air is allowed to escape to release the brakes, this spring reacts and pushes the piston in again.

5. Q. Where is the compressed air kept ready for use in the automatic air brake?

A. In the main reservoir on the locomotive, in the smaller or auxiliary reservoir on each car, and in the train pipe.

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6. Q. Where does the compressed air come from directly that enters into the brake cylinder when the automatic brake is applied?

A. It comes from the auxiliary reservoir on each car in service application, and from the auxiliary reservoir and train pipe in emergency application.

7. Q. How does it get into the auxiliary reservoir?

A. It is furnished from the main reservoir on the locomotive through the train pipe and triple valve when the brakes are released.

8. Q. How is the automatic brake applied and released?

A. The automatic brake is applied by reducing the air pressure in the train pipe below that in the auxiliary reservoir, and is released by raising the train pipe pressure above that remaining in the auxiliary reservoir.

9. Q. Why does the compressed air not enter directly into the brake cylinder from the train pipe?

A. Because the triple valve used with the automatic brake prevents the air from entering directly from the train pipe to the brake cylinder when the pressure in the train pipe is maintained or increased.

10. Q. What other uses has the triple valve ?

A. It causes the brake cylinder to be opened to the atmosphere under each car, to release the brakes when the pressure in the train pipe is made greater than that in the auxiliary reservoir, and it opens communication from the train pipe to the auxiliary reservoir by the same movement; when the pressure in the train pipe is reduced it closes the openings from the train pipe to the auxiliary reservoir and from the brake cylinder to the atmosphere, and then opens the passage between the auxiliary reservoir and the brake cylinder by the same movement, so as to admit the air and apply the brakes.

11. Q. How many forms of triple valves are there in use, and what are they called?

A. Two; the plain triple and the quick-action triple.

12. Q. How can you tell the plain triple from the quick-action triple?

A. The plain triple has a four-way cock in it, with a handle for operating the cock; the quick-action triple has no such cock in it, but there is a plug cock in the cross-over pipe leading from the train pipe to the triple, when the quick-action triple is used.

13. Q. What are these cocks for in both cases?

A. They are to be used to cut out brakes on one car, without interfering with other brakes on the train, if the brake on that car has become disabled.

14. Q. How does the cock handle stand in the plain triple when the pipe is open for automatic action?

A. It stands in a horizontal position.

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15. Q. In what position does the same handle stand when the brakes are cut out by closing the cock?

A. It stands at an inclined position midway between horizontal and vertical.

16. Q. How does the handle in the plug cock in the cross-over pipe, used with the quick action triple, stand for automatic action?

A. It stands with the handle crosswise with the pipe, and groove in plug lengthwise when cock is open.

17. Q. How does the handle and groove stand when the cock is closed and brake cut out of action?

A. It stands with the handle lengthwise of cross-over pipe, and the groove crosswise when closed.

18. Q. How is the train pipe coupled up between the cars?

A. By means of a rubber hose on each end of the train pipe, fitted with a coupling at the loose end.

19. Q. How is the train pipe closed at the rear end of train?

A. By closing the cock in the train pipe at the rear end of last car.

20. Q. How many such train pipe cocks are there to a car, on the air brake train pipe and on the air signal train pipe, and why?

A. Two for each pipe on each car, because either end of any car may sometimes be at the rear end of the train.

21. Q. How many kinds of train pipe cocks are there in use at the ends of the cars?

A. Two.

22. Q. Describe each and give the position of the handle and groove for open and closed in each case.

A. The older form of train pipe cock is a straight plug cock in the train pipe, not far from the hose connection; the handle stands crosswise with the pipe when it is open, and lengthwise with the pipe when closed; it is now found principally on the air signal pipe. The other form of train pipe cock now used on the air brake pipe is an angle cock placed at the end of the train pipe and close to the hose. The handle of the angle cock stands lengthwise with the pipe when open, and crosswise with the pipe when closed. The groove is also a guide to tell whether open or closed.

23. Q. What uses have these train pipe cocks besides to close the pipe at the end of the train?

A. They are used to close the train pipe at both sides of any hose coupling which is to be parted, as when the train is cut in two.

24. Q. Why is it necessary to close the train pipe on both sides of the hose coupling before it is parted?

A. To prevent the escape of air from the train pipe, which would apply the brakes.

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25. Q. How must the hose coupling be parted when it is necessary to do so, and why?

A. The air brake must first be released on the train from the locomotive, then the adjacent train pipe cocks must both be closed and the coupling must be parted by hand, to prevent the possibility of injury to the rubber gasket in the coupling.

26. Q. Why must the brakes be fully released before uncoupling the hose between the cars?

A. Because if the brakes are applied upon a detached car they can not be released without bleeding the auxiliary reservoir.

27. Q. In coupling or uncoupling the hose between cars, what must be done if there is ice on the couplings?

A. The ice must first be removed and the couplings thawed out, so as to prevent injury to the rubber gaskets in uncoupling, and to insure tight joints in coupling the hose.

28. Q. What must be done with a hose coupling which is not coupled up, such as the rear hose of a train, or any hose on a car which is standing or running, but not in use?

A. It must be placed in the dummy coupling if provided for in such manner that the flat pad on the dummy will close the opening in the coupling.

29. Q. What pressure should be carried in the train pipe and auxiliary reservoir?

A. The authorized pressure, as per special instructions.

30. Q. Why should the authorized pressure be maintained?

A. Because this pressure is necessary to get the full braking force which each car is capable of using, and, if it be exceeded, there will be danger of sliding the wheels.

31. Q. How much pressure can be obtained in the brake cylinder by the service application of the brakes with seventy pounds in the auxiliary reservoir?

A. About fifty pounds to the square inch, with an 8-inch piston travel.

32. Q. Why can only fifty pounds pressure be obtained under these circumstances?

A. Because the air at seventy pounds pressure in the auxiliary reservoir expands into an additional space when the auxiliary reservoir is opened to the brake cylinder, and when the pressure has become equalized it is thus reduced to fifty pounds.

33. Q. How much must the train pipe pressure be reduced, in order to get fifty pounds pressure in the brake cylinder, in ordinary service?

A. Twenty pounds.

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34. Q. Can the brakes be applied so as to get only a portion of this fifty pounds pressure in the brake cylinder, and how?

A. They can be so applied by reducing the train pipe pressure less than twenty pounds.

35. Q. If the train pipe pressure be reduced ten pounds, what will be the pressure in the brake cylinder?

A. About twenty-five pounds.

36. Q. How is this graduated action obtained?

A. By means of the graduating valve in the triple valve.

37. Q. Is it important to keep all the air brake apparatus tight and free from leaks?

A. Yes.

38. Q. Why is this important?

A. In order to get full service from the air brakes, and to prevent the waste of air, and also to prevent the brakes applying automatically by reason of leak in the train pipe.

39. Q. Is it important to know that the train pipe is open throughout the train and closed at the rear end before starting out?

A. Yes, this is very important.

40. Q. Why is this very important?

A. Because if any cock in the train pipe were closed, all the brakes back of the cock which is closed would be prevented from working.

41. Q. How can you ascertain that the train pipe cocks are all open when the train is made up?

A. By testing the brakes; that is, by applying and releasing them, and observing whether they all operate.

42. Q. Do you understand that no excuse will be acceptable for starting out the train without first testing the air brakes?

A. Yes.

43. Q. Why is this rule absolute?

A. Because the safety of passengers and of property depends upon the brakes being properly coupled up and in an operating condition before the train is started.

44. Q. At what other times should the brakes be tested?

A. After each change in the make-up of the train and before starting the train down certain designated grades.

45. Q. From where does the air signal apparatus receive its pressure?

A. From the main air reservoir through the reducing valve.

46. Q. How much air pressure should be carried in the air signal train pipe?

A. The authorized pressure.

47. Q. Is it important that this train pipe and its connections be also kept tight?

A. Yes.

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48. Q. After taking up the slack of the brake shoes, how far should the brake piston travel in the cylinders on cars and tenders with a full application of the brake?

A. Not less than six inches, nor more than nine inches.

49. Q. What would happen if the piston traveled less than six inches when brakes are fully applied?

A. A partial application of the brakes might not force the piston beyond the leakage groove in the brake cylinder provided for the escape of small amounts of air.

50. Q. Why should the piston travel not be permitted to exceed nine inches on passenger cars, tenders, or freight cars?

A. Because if it travels farther than this when sent out, a little wear of the brake shoes will cause the piston to travel far enough to rest against the back cylinder head when the brakes are applied, and this cylinder head would then take the pressure instead of its being brought upon the brake shoes.

51. Q. How far should the driver brake piston travel with a full application of the brakes, and why?

A. Not less than two inches nor more than three and one-half inches for the cam type of brake, and from four to six inches for other forms.

52. Q. If the brakes stick upon any car so that the engineman can not release them at any time, how should they be released?

A. By opening the release cock in the auxiliary reservoir and holding it open until air begins to escape from the triple valve, and then closing it again.

53. Q. What is the pressure retaining valve, and what is its use?

A. The pressure retaining valve is a small valve placed at the end of a pipe from the triple valve, through which the exhaust takes place from the brake cylinder. It is used to retard the brake release on heavy grades, and holds the brakes partially applied, so as to allow more time for the engineman to recharge the auxiliary reservoir.

54. Q. What precautions are necessary on every train in regard to hose couplings?

A. Every train must carry at least two extra hose and couplings complete, for use in replacing any hose couplings which may fail or become disabled. These extra hose and couplings to be carried on such part of the train as is required by the rules and regulations.

SPECIAL FOR ENGINEMEN.

55. Q. How should the air pump be started?

A. It should be started slowly, so as to allow the condensation to escape from the steam cylinder and prevent pounding, which is more likely to occur when the air pressure is low.

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56. Q. Why should the piston rod on the air pump be kept thoroughly packed?

A. To prevent the waste of air and steam.

57. Q. How should the steam cylinder of the air pump be oiled, and what kind of oil should be used?

A. It should be oiled as little as necessary through a sight-feed lubricator, and cylinder oil should be used.

58. Q. How should the air cylinder of the air pump be oiled; what kind of oil?

A. It should be supplied with valve oil as often as necessary, through a cup provided for that purpose. Also, a well saturated swab should be kept on the piston rod. Lard oil, and other animal or vegetable oils should not be used, as their use causes the brake valve and the triple valves to gum up. The oil must never be introduced through the air inlet ports, as this practice would cause the pump valves to gum up.

59. Q. What regulates the train pipe pressure?

A. The train pipe governor, or feed valve, provided for that purpose.

60. Q. Why should the authorized pressure be carried in train pipe?

A. Because this pressure produces the strongest safe pressure of the brake shoes upon the wheels. A higher train pipe pressure is liable to cause the wheels to slide.

61. Q. What does the feed valve attachment on the brake valve accomplish?

A. When properly adjusted it restricts the train pipe pressure to the authorized amount, with the brake valve handle carried in running position.

62. Q. How often should the brake valve be thoroughly cleaned and oiled?

A. At least once every two months.

63. Q. If the main valve in the brake valve is unseated by dirt or by wear, what may be the result, and what should be done?

A. It may be impossible to get the excess pressure; when the brakes have been applied they may keep applying harder until full on, or when they have been applied they may release. The main valve should be thoroughly cleaned, and if worn it should be faced to a seat.

64. Q. If the piston in the brake valve becomes gummed up or corroded from neglect to clean it, what will be the result?

A. It will be necessary to make a large reduction of pressure through the preliminary exhaust port before the brakes will apply at all, and then the brakes will go on too hard and will have to be released.

65. Q. How and why should the train pipe under the tender always be blown out thoroughly before connecting up to the train?

A. By opening the angle cock at the rear end of the tender and allowing the air from the main reservoir to blow through. This blows

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out the oil, water, scale, etc., which may accumulate in the pipe, and which would be blown back into the train pipe and triple valves if not removed before coupling to the train.

66. Q. When the locomotive is coupled to the train, why is it necessary to have excess pressure in the main reservoir?

A. So that the brakes will all be released and the train quickly charged when the engineman's valve is placed in the release position.

67. Q. Why should the driver brakes be operated automatically with the train brake?

A. Because it adds greatly to the braking force of the train, and the brakes can be applied alike to all the wheels for ordinary stops, and in an emergency the greatest possible braking force is at once obtained by one movement of the handle.

68. Q. In making a service application of the brakes, how much reduction of the train pipe pressure from seventy pounds does it require to get the brakes full on?

A. About twenty-five pounds reduction.

69. Q. What should the first reduction be in such an application?

A. Not less than five pounds, so as to insure moving the pistons in the brake cylinders past the leakage grooves.

70. Q. What is the result of making a greater reduction of pressure than twenty-five pounds?

A. A waste of air in the train pipe, without getting any more braking force, and therefore requiring more air to release the brakes.

71. Q. How many applications of the brakes are necessary in making a stop?

A. One or two applications.

72. Q. Why is it dangerous to apply and release the brakes repeatedly in making stops?

A. Because every time the brakes are released the air in the brake cylinders is thrown away, and if it is necessary to apply them again before sufficient time has elapsed to recharge the auxiliary reservoirs the application of the brakes will be weak, and after a few such applications the brakes are almost useless on account of the air having been exhausted from the auxiliary reservoirs.

73. Q. In releasing and recharging the train, how long should the handle of the brake valve be left in the release position?

A. Until the train pipe pressure has risen nearly to authorized pressure.

74. Q. In making service stops with passenger trains, why should you release the brakes just before coming to a full stop?

A. So as to prevent stopping with a lurch; it also requires less time for the full release of the brakes after stopping.

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75. Q. In making stops with freight trains, why should the brakes not be released until after the train has come to a full stop?

A. Because long freight trains are apt to be parted by releasing the brakes before rear brakes are fully released.

76. Q. In making service stops, why must the handle of the brake valve not be moved past the position for service applications?

A. So as to prevent unnecessary jerks to the train and the emergency action of the triple valve when not necessary.

77. Q. If you find the train dragging from the failure of the brakes to release, how can you release them?

A. By placing the handle of the brake valve in full release position for a few seconds and returning it to the running position, if the train pipe pressure is not up to the authorized amount; but if maximum pressure is in train pipe, the brakes should be applied with from five to ten pounds reduction, according to the length of train pipe, and released in the usual manner.

78. Q. When the brakes go on suddenly when not operated by the brake valve, and the gauge pointer falls back, what is the cause, and what should you do?

A. Either a hose has burst, or a conductor's valve has been opened, or the train has parted. In any event, the engine throttle should be closed and the handle of the brake valve should immediately be placed on lap position to prevent escape of air from main reservoir.

79. Q. Are the brakes liable to stick after an emergency application, and why?

A. The brakes are harder to release after an emergency application because they are on with full force and it requires higher pressure than usual in the train pipe to release them again. In this case it is necessary always to have in reserve the excess pressure of the main reservoir to aid in releasing the brakes. With the quick-action triple valve this is especially necessary, because air from the train pipe as well as from the auxiliary reservoir is forced into the brake cylinder when a quick application of the brake is made, thus increasing the pressure in the brake cylinder without the usual reduction of pressure in the auxiliary reservoir, and requiring a correspondingly high pressure in the train pipe afterward to cause the brakes to be released.

80. Q. In using the brakes to steady the train while descending grades, why should the air pump throttle be kept well open?

A. So that the pump may quickly accumulate a full pressure in the main reservoir for use in recharging the train pipe and auxiliary reservoir when the brakes have been released again.

81. Q. In descending a grade, how can you best keep the train under control?

A. First, by commencing the application of the brakes early, so as

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to prevent too high a speed being reached; secondly, by making an initial reduction that will lightly apply all brakes in the train, and by slowing the train down just before it is necessary to charge the auxiliary reservoir, so as to give time enough to refill same before much speed is again attained.

82. Q. If the train is being drawn by two or more locomotives, upon which locomotives should the brakes be controlled, and what must the engineman of the other locomotive do?

A. The brakes must be controlled by the leading locomotive, and the enginemen of the following locomotives must close the cock in the train pipe just below the brake valves. The latter must always keep the pump running and in order, and main reservoir charged with pressure, with the brake valve in the running position, so that he may quickly operate the brakes if called upon to do so.

83. Q. If the air signal whistle gives only a weak blast, what is the probable cause?

A. Either the reducing valve is out of order so that the pressure is considerably less than forty pounds, or the whistle itself is filled with dirt or not properly adjusted, or the port under the end of signal valve is partly closed by gum or dirt.

84. Q. If the reducing valve for the air signal is allowed to become clogged up with dirt, what will the result probably be?

A. The signal pipe might get the full main reservoir pressure, and the whistle will blow when the brakes are released.

85. Q. If you discover any defect in the air brake or signal apparatus while on the road, what must be done?

A. If it is something that can not be readily remedied at once, it must be reported to the Enginehouse Foreman as soon as the run is completed.

86. Q. What is the result if water be allowed to collect in the main reservoir of the brake apparatus?

A. The room taken up by the water reduces the capacity for holding air, and the brakes are more liable to stick. In cold weather also the water may freeze and prevent the brakes from working properly.

SPECIAL FOR ENGINE REPAIRMEN.

87. Q. How often must the air brake and signal apparatus on locomotives be examined?

A. After each trip.

88. Q. Under what pressure must it be examined?

A. Under full pressure.

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89. Q. Should the train pipe pressure exceed the maximum, where would you look for the cause of the trouble?

A. In the devices controlling train pipe pressure.

90. Q. How often must the main reservoir and the drain cup under the tender be drained?

A. After each trip.

91. Q. How often must the triple valves and the cylinders of the driver and tender brakes be cleaned and lubricated?

A. They must be thoroughly cleaned and lubricated once every six months. If the driver brake cylinders are so located that they become hot from the boiler, they may acquire lubrication more frequently.

92. Q. If there are any leaks in the pipe joints or anywhere in the apparatus, what must you do?

A. Repair them before the locomotive goes out.

93. Q. How is the brake shoe slack of the cam driver brake taken up, and what precautions are necessary?

A. By means of the cam screws, and it is necessary to lengthen both alike, so that when the brake is applied the point of contact with the cams will be in a line with the piston rod.

94. Q. How is the brake shoe slack of driver brakes on a locomotive with more than two pairs of driving wheels taken up?

A. By means of a turnbuckle or screw in the connecting rods.

95. Q. How is the slack of the tender brake shoes taken up?

A. By means of the dead truck levers; if they will not take it up enough, it must be taken up in the underneath connection, and then adjusted by the dead lever.

96. Q. How far should the driver brake piston travel in applying the brakes?

A. Not less than two inches, nor more than three and one-half inches with the cam type of brake, and from four to six inches with other forms.

97. Q. What travel of piston should the tender brakes be adjusted for?

A. Not less than two inches, nor more than three and one-half inches with the cam type of brake, and from four to six inches with other eight inches.

SPECIAL FOR TRAINMEN.

98. Q. How should you proceed to test the air brakes before starting out, after a change in the make-up of a train, or before descending certain specially designated grades?

A. After the train has been fully charged with air, the engineman must be required to apply the brakes; when he has done so the brakes

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must be examined upon each car to see that the air is applied and that the piston travel is not less than six nor more than nine inches. The engineman must then be required to release the brakes; after he has done so, each brake must be examined again to see that all are released. The engineman and conductor must then be notified that the brakes are all right, if they are found so. (In testing passenger brakes, the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.)

99. Q. In starting out a passenger train from an inspection point, how many cars must have the brakes in service?

A. Every car in the train.

100. Q. When might you cut out a brake upon a passenger car?

A. Never, unless it gets out of order while on the run, in which case it must be reported to the inspector at the end of the run, or upon the first opportunity which may give sufficient time to repair it.

101. Q. If a hose bursts upon the run what must be done, if the train is in a safe place?

A. The hose must first be replaced by a good one, and the engineman then signaled to release the brakes. The train must not proceed until the brakes have been reconnected and tested upon the train to see that all are working properly.

102. Q. If the train is not in a safe place when the hose bursts, what must be done?

A. The train pipe cock immediately ahead of the burst hose must be closed and the engineman signaled to release the brakes. The brakes at the rear of the burst hose must then be released by bleeding the auxiliary reservoirs, and the train must then proceed to a safe place to replace the hose and connect up the brakes, after which the brakes must be tested.

103. Q. If the train breaks in two, what must be done?

A. The cock in the train pipe at the rear end of the first section must be closed and the engineman signaled to release the brakes. The two parts of the train must then be coupled, the hose connected and the brakes again released by the engineman. When it is ascertained that the brakes are all released, the train may proceed.

104. Q. Explain how the pressure-retaining valves are thrown into action or thrown out of action, and when this must be done.

A. The pressure-retaining valve is thrown into action by turning the handle of the valve to a horizontal position, and it is thrown out of action again by placing this handle in a vertical position pointing downward. This handle should be placed in a horizontal position at the top of a heavy grade, and it should always be returned to a vertical position at the foot of the grade, as otherwise the brakes will drag on any cars which still have the handle of the pressure-retaining valve in the horizontal position.

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105. Q. If the brake of any car is found to be defective on the run, how should you proceed to cut it out?

A. By closing the cock in the cross-over pipe of the quick-action brake, or in the triple valve of the plain automatic brake, and then opening the release cock in the auxiliary reservoir upon that car, leaving it open, if a passenger car, or holding it open until all the air has escaped from it, if a freight car.

106. Q. When it is necessary to cut out a defective brake upon a car, why should it always be cut out at the triple valve and never by the train-pipe cock at the end of the car, even if it is the last car of the train?

A. The train pipe should always be open from the locomotive to the rear end of the last car, so that if the train breaks in two the brakes will be automatically applied before the parts of the train have separated sufficiently to permit damage to be done by their coming together again, and so that the brakes may be applied with the conductor's valve upon any car.

107. Q. Should the train pipe burst under any car, what must be done?

A. The train must proceed to the nearest switching point, using the brakes upon the cars ahead of the one with the burst pipe, where the car with the burst pipe must be switched to the rear of the train; the hose must then be coupled up to the rear car and the cock at the rear end of the next to the last car opened, and the cock at the forward end of the last car closed, so that if the train should part between the last two cars the brakes will be applied.

108. Q. What is the conductor's valve, and what is its use?

A. It is a valve at the end of a pipe leading from the train-brake pipe upon each passenger car; it is to be opened from the car in any emergency when it is necessary to stop the train quickly, and only then. When used it should be held open until the train is stopped, and then it should be closed.

109. Q. What is the air signal for, and how is it operated?

A. It is to signal the engineman, in place of the old gong signal, and it is operated by pulling directly downward on the cord for one second and releasing immediately, allowing three full seconds to elapse between pulls.

110. Q. If the discharge valve on the air-signal system is out of order or leaking on any car, how can you cut it out?

A. By closing the cock in the branch pipe leading from the train-signal pipe to the discharge valve; to do so the handle of this cock should be placed lengthwise with the pipe.

111. Q. How is the slack taken up so as to secure the proper adjustment of piston travel?

A. By means of the dead-truck lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the

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adjustment then made by the dead-truck lever. Where automatic slack adjusters are applied to any car, such adjusters must be fully released before the slack is taken up elsewhere.

SPECIAL FOR INSPECTORS.

112. Q. Do you understand that no passenger train may be started out with any of the brakes cut out of service?

A. I do.

113. Q. Why is it important that no leaks should exist in the air brake service?

A. Because they would interfere with the proper working of the brakes and might cause serious damage.

114. Q. What must be done with the air brake or air-signal couplings when not united to other couplings, on cars equipped with dummy couplings?

A. They must be secured in the dummy coupling, so that the face of the dummy coupling will cover the opening of the hose coupling so as to prevent dust and dirt from entering the hose.

115. Q. If the air issues from the exhaust port of the quick-action triple valve when the brakes are off, what is the cause?

A. It is probably due to dirt on the rubber seated emergency valve.

116. Q. How often must the cylinder and triple valves be examined, cleaned and lubricated?

A. As often as once every six months on passenger cars and once in twelve months on freight cars. The dates of the last cleaning and lubrication must be marked with white paint on the cylinders.

117. Q. What is the difference between the quick-action passenger and freight triple valve?

A. The passenger triple valves have larger ports and slide valves.

118. Q. How may a passenger triple valve be distinguished?

A. By having one exhaust outlet, or suitable lettering designating the class of service.

119. Q. How may a freight triple valve be distinguished?

A. By its two exhaust outlets, one being plugged.

120. Q. When should the graduating sprihg of the triple valve be replaced with a new one?

A. When it is worn or rusted out, or not of standard size.

121. Q. To what travel of piston must the brakes be adjusted?

A. Not less than six inches, and this adjustment must be made whenever the piston travel is found to exceed nine inches.

122. Q. How is the slack taken up so as to secure this adjustment?

A. By means of the dead-truck lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the

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adjustment then made by the dead-truck lever. Where automatic slack adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere.

123. Q. What are the different holes in the outer end of the cylinder levers for, and why must the connections be pinned to the proper hole for each car?

A. These holes are to enable the adjustment of the brake pressure to be made according to the weights of the different cars. The connection must be made to the proper hole in each case, according to the weight of the car, so as to give proper braking power, otherwise the brake will be inefficient, or the wheels may be slid under the cars.

124. Q. How many sizes of high speed brake-reducing valves are there in use, and how will it be known to which size of cylinders they should be connected?

A. There are three sizes, namely, one for 8-inch, one for 10-inch and 12-inch, and a third for 14-inch and 16-inch cylinders, and they can be distinguished by the raised figures cast on their body.

125. Q. To what pressure must the high speed brake-reducing valve be adjusted on passenger equipment cars?

A. The authorized pressure.

BASIC PRINCIPLES RELATING TO THE HANDLING OF APPRENTICES.

At the convention of 1898 a code of apprenticeship rules was adopted as the Recommendation of the Association. In 1908 a series of basic principles relating to the handling of apprentices was adopted in lieu of the former code.

1. To develop from the ranks in the shortest possible time carefully selected young men for the purpose of supplying leading workmen for future needs, with the expectation that those capable of advancement will reveal their ability and take the places in the organization for which they are qualified.

2. A competent person must be given the responsibility of the apprenticeship scheme. He must be given adequate authority, and he must have sufficient attention from the head of the department. He should conduct thorough shop training of the apprentices, and in close connection therewith should develop a scheme of mental training, having necessary assistance in both. The mental training should be compulsory, and conducted during working hours at the expense of the company.

3. Apprentices should be accepted after careful examination by the apprentice instructor.

4. There should be a probationary period before apprentices are finally accepted; this period to apply to the apprentice term if the candidate is accepted. The scheme should provide for those candidates for appren-

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ticeship who may be better prepared as to education and experience than is expected of the usual candidate.

5. Suitable records should be kept of the work and standing of apprentices.

6. Certificates or diplomas should be awarded to those successfully completing the apprentice course. The entire scheme should be planned and administered to give these diplomas the highest possible value.

7. Rewards in the form of additional education, both manual and mental, should be given apprentices of the highest standing.

8. It is of the greatest importance that those in charge of apprentices should be most carefully selected. They have the responsibility of preparing the men on whom the roads are to rely in the future. They must be men possessing the necessary ability, coupled with appreciation of their responsibility.

9. Interest in the scheme must begin at the top, and it must be enthusiastically supported by the management.

10. Apprenticeship should be considered as a recruiting system, and greatest care should be taken to retain graduated apprentices in the service of the company.

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LUMBER SPECIFICATIONS.

In 1910 a joint committee of the American Railway Master Mechanics' Association and this Association working in conjunction with the Railway Storekeepers' Association and the various Lumber Manufacturers' Associations, submitted specifications and grading rules for car and locomotive lumber, which, on motion, were ordered submitted to letter ballot and adopted as Recommended Practice. They are as follows:

In order to have standard descriptions of the various woods used by railroads, the following standard names for car and locomotive lumber were agreed upon by the Joint Committee:

LUMBER SPECIFICATIONS.

Description of various woods used by railroad companies for car and locomotive lumber.

1. *Ash* .....To cover White, Black, Blue, Green and Red Ash.
2. *Basswood* .....To cover Linden, Linn, Lind or Lime-tree.
3. *Beech* .....To cover Red and White Beech.
4. *Birch* .....To cover Red, White, Yellow and Black Birch.
5. *Buckeye.* .....To cover wood from Horse-chestnut tree.
6. *Butternut* .....To cover wood from tree of that name, also known as White Walnut.
7. *Cherry* .....To cover Sweet, Sour, Red, Black and Wild Cherry.
8. *Chestnut* .....To cover wood from tree of that name.
9. *Cottonwood* .....To cover wood from tree of that name. (Do not confuse with Popple or Poplar.)
10. *Cypress* .....To cover Red, Gulf, Yellow and East Coast Cypress, also known as Bald Cypress.
11. *Elm—soft* .....To cover White, Water, Gray, Red or Slippery and Winged Elm.
12. *Elm—rock* .....To cover Rock or Cork Elm.
13. *Douglas Fir* .....To cover Yellow, Red, Western, Washington, Oregon, Puget Sound Fir or Pine, Norwest and West Coast Fir.
14. *Gum* .....To cover Red Gum, Sweet Gum or Satin Walnut.
15. *Hemlock* .....To cover Southern and Eastern Hemlock; that is, Hemlock from all States east of and including Minnesota.
16. *Western Hemlock* ....To cover Hemlock from the Pacific Coast.
17. *Hickory* .....To cover Shellbark, Kingnut, Mockernut, Pignut, Black, Shagbark and Bitternut.
18. *Western Larch* .....To cover the species of Larch or Tamarack from the Rocky Mountain and Pacific Coast regions.

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19. *Maple — soft* .....To cover Soft and White Maple.
20. *Maple — hard* .....To cover Hard, Red, Rock and Sugar Maple.
21. *White Oak* .....To cover White, Burr or Mossy Cup, Rock, Post or Iron, Overcup, Swamp Post, Live, Chestnut or Tan Bark, Yellow or Chinquapin and Basket or Cow Oak.
22. *Red Oak* .....To cover Red, Pin, Black, Water, Willow, Spanish, Scarlet, Turkey, Black Jack or Barn and Shingle or Laurel Oak.
23. *Pecan* .....To cover wood from tree of that name.
24. *Southern Yellow Pine*.To cover Long-leaf and Short-leaf Yellow Pine grown in the Southern States.
25. *White Pine* .....To cover wood from tree of that name grown in Maine, Michigan, Wisconsin, Minnesota and Canada.
26. *Norway Pine* .....To cover Norway or Red Pine grown in Michigan, Minnesota, Wisconsin and Canada.
27. *Idaho White Pine* ....To cover variety of White Pine grown in western Montana, northern Idaho and eastern Washington.
28. *Western Pine* .....To cover timber known as White Pine grown in Arizona, California, New Mexico, Colorado, Oregon and Washington; sometimes known as Western Yellow or Ponderosa Pine, or California White Pine or Western White Pine.
29. *Poplar* .....To cover wood from the Tulip Tree, otherwise known as Whitewood, Yellow Poplar and Canary Wood.
30. *Redwood* .....To cover wood from tree of that name.
31. *Spruce* .....To cover Eastern Spruce; that is, the Spruce timber coming from points east of and including Minnesota and Canada, covering White, Red and Black Spruce.
32. *Western Spruce* .....To cover the Spruce timber from the Pacific Coast.
33. *Sycamore* .....To cover wood from tree of that name, otherwise known as Buttonwood.
34. *Tamarack* .....To cover Tamarack or Eastern Tamarack, grown in States east of and including Minnesota.
35. *Tupelo* .....To cover Tupelo Gum and Bay Poplar.
36. *Walnut* .....To cover Black Walnut (for White Walnut, see Butternut).

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CLASSIFICATION, GRADING AND DRESSING RULES FOR NORTHERN PINE CAR MATERIAL, INCLUDING WHITE AND NORWAY PINE AND EASTERN SPRUCE.

1. *Norway Pine.* To cover Norway or Red Pine grown in Michigan, Minnesota, Wisconsin and Canada.

White Pine to cover wood from tree of that name grown in Maine, Michigan, Wisconsin, Minnesota and Canada.

Spruce to cover Eastern Spruce; that is, the Spruce timber coming from points east of and including Minnesota and Canada, covering White, Red and Black Spruce.

2. *Northern Pine Lumber* shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, *except where otherwise expressly stipulated between buyer and seller.*

3. Recognized defects in Northern Pine are knots, knotholes, splits, shake, wane, wormholes, pitch pockets, torn grain, loosened grain, sap, sap stain, checks and rot.

KNOTS.

4. Knots shall be classified as pin, small and large or coarse, as to size, and round or spike, as to form, and as sound, loose, encased, pith and rotten, as to quality.

5. A pin knot is sound and shall not exceed ½ inch in diameter.

6. A small knot is larger than a pin knot and shall not exceed 1½ inches in diameter.

7. A large or coarse knot is one of any size over 1½ inches in diameter.

8. A round knot is oval or circular in form.

9. A spike knot is one sawn in a lengthwise direction.

The mean or average diameter of knots shall be considered in applying and construing these rules.

10. A sound knot is one solid across its face; is as hard as the wood it is in and is so fixed by growth or position that it will retain its place in the piece.

11. A loose knot is not firmly set, but still retains its place in the piece.

12. A pith knot is a sound knot with a pith hole not more than ¼ inch in diameter.

13. An encased knot is one surrounded wholly by bark or pitch.

14. A rotten knot is one not as hard as the wood it is in.

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EXHIBIT A — NORTHERN WHITE PINE.

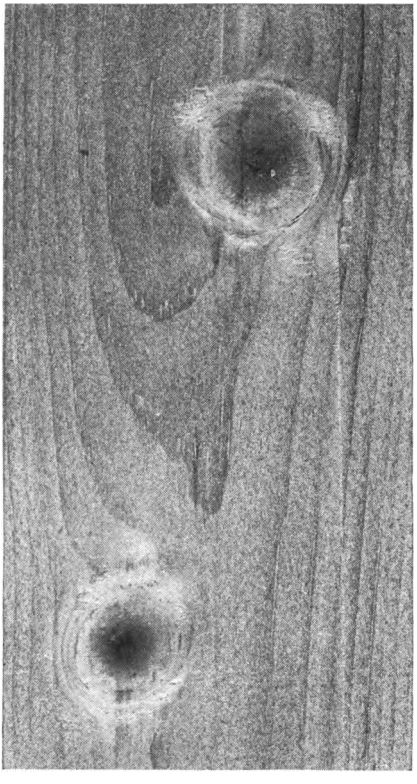


FIG. 1.— PIN KNOTS.

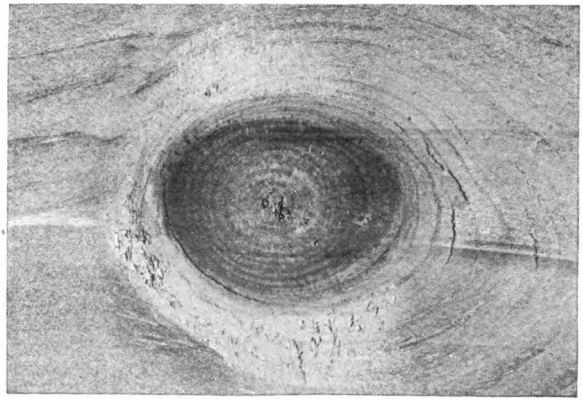


FIG. 2.— SMALL AND ROUND KNOT.

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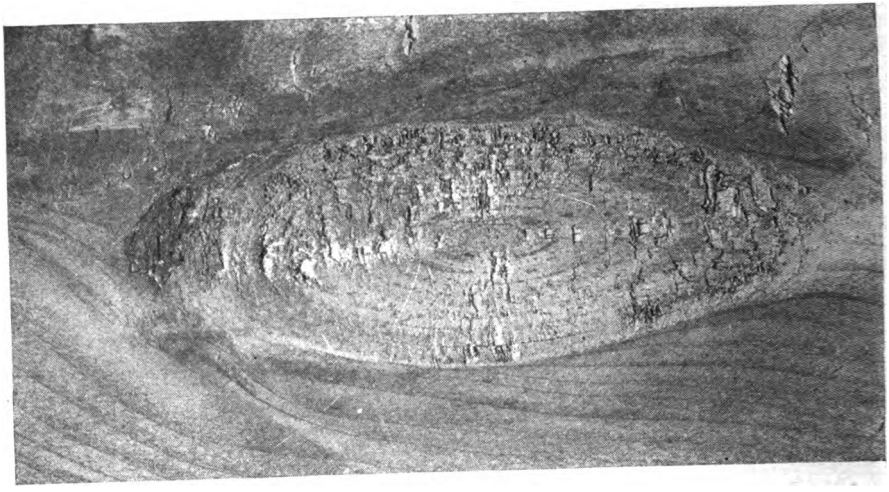


FIG. 3.— LARGE KNOT.



FIG. 4.— SPIKE KNOT.

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FIG. 5.— SOUND KNOTS.

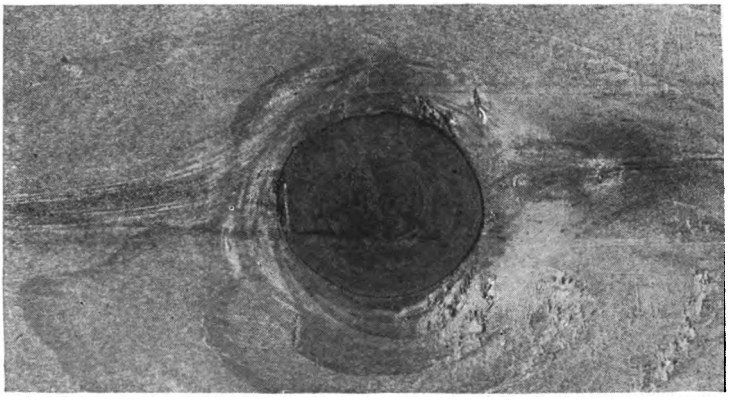


FIG. 6.— LOOSE KNOT.

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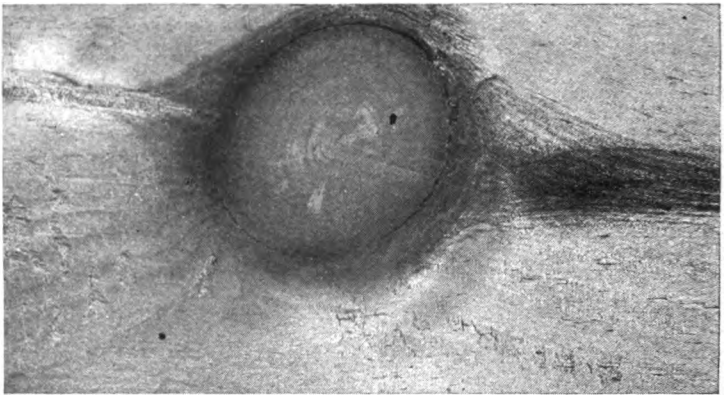


FIG. 7.— ENCASED KNOT.



FIG. 8.— SMALL PITCH POCKET.

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PITCH.

15. Pitch pockets are openings between the grain of the wood containing more or less pitch or bark, and shall be classified as small, standard and large pitch pockets.

16. A small pitch pocket is one not over ⅛ of an inch wide.

17. A standard pitch pocket is one not over ⅜ of an inch wide, or 3 inches in length.

18. A large pitch pocket is one over ⅜ of an inch wide or over 3 inches in length.

19. A pitch pocket showing open on both sides of the piece ⅛ of an inch or more in width shall be considered the same as a knothole.

WANE.

20. Wane is bark, or the lack of wood, from any cause, on edge.

SAP.

21. White or bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

MISCELLANEOUS.

22. Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

23. All lumber for uses described in these rules shall be inspected on the face side to determine the grade, and the face side is the side showing the best quality or appearance.

24. Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of the cut, and as usually found should not be classed as torn grain, and shall not be considered a defect.

25. Torn grain consists in a part of the wood being torn out in the dressing. It occurs around knots and curly places, and is of four distinct characters; slight, medium, heavy and deep.

Slight torn grain shall not exceed 1-32 of an inch in depth, medium 1-16 of an inch, and heavy ⅛ of an inch. Any torn grain heavier than ⅛ of an inch shall be termed deep.

26. The grade of all regular stock shall be determined by the number, character and position of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the coarsest pieces *such grades may contain,* but the average quality of the grade shall be midway between the highest and lowest pieces allowed in the grade.

27. Lumber and timber sawed for specific purposes must be inspected with a view to its adaptability for the use intended.

28. *All dressed stock shall be measured strip count, viz.: Full size of rough material necessarily used in its manufacture.*

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29. Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or mill work will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

30. The foregoing general observations shall apply to and govern the application of the following rules. The rules referred to under Sections 31, 32, 33, 34 and 35 govern 4 or 6 inch strips, and are intended to cover strips used for car siding, car lining and car roofing.

B and Better White Pine.

31. Material of this grade shall be practically clear and free of all defects, except will admit of not exceeding four pin knots, and bright sap not to exceed 25 per cent of the face of the piece.

C and Better Norway Pine.

32. Bright sap is no defect in this grade and stained sap will be admitted to the extent of not exceeding 1-5 the surface of the face of the piece, if not in combination with other defects. This grade shall be free from shake, rot and splits, but will admit of not exceeding four pin knots.

No. 1 Common White Pine, Norway Pine and Eastern Spruce.

33. This grade admits of small sound knots, but shall be free from large or coarse knots, knotholes, should have practically no shake, wane or rot, but will admit of bright sap to any extent.

No. 2 Common White Pine, Norway Pine and Eastern Spruce.

34. This grade is similar to No. 1, described above, except that it will admit of spike knots, bright or stained sap, slight shake, slight wane on reverse side, but not a serious combination of any of these defects.

No. 3 Common White Pine, Norway Pine and Eastern Spruce.

35. This grade, in addition to the defects mentioned in No. 2, described above, will also admit of large or coarse knots, more shake, sap, wane on reverse side that does not affect the tongue or groove and torn or loosened grain, checks, pin wormholes and splits, but no loose knots or knotholes, nor a serious combination of the defects named.

No. 1 Common Norway Pine Car Decking or Flooring.

36. This grade will admit of sound knots, any amount of sap, and shall be free from shake, wane, rot and large or coarse spike knots.

37. STANDARD LENGTHS.

CAR SIDING — 8, 9, 10 and 12 feet or multiples.
CAR ROOFING — 5 feet or multiples.
CAR LINING — 8, 9, 10, 12, 14, 16, 18 and 20 feet or multiples.
CAR DECKING — 9 and 10 feet or multiples.

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All orders shall be shipped in standard lengths, unless otherwise specified, but no lengths of either car siding, lining or roofing shall be shipped except in the lengths specified or multiples thereof. Those who do not desire stock shipped in multiple lengths should so specify.

CLASSIFICATION, GRADING AND DRESSING RULES FOR SOUTHERN YELLOW PINE CAR MATERIAL.

1. *Southern Yellow Pine.*— To cover Long-leaf and Short-leaf Yellow Pine grown in the Southern States.

2. *Southern Yellow Pine Lumber* shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, *except where otherwise expressly stipulated between buyer and seller.*

3. Recognized defects in Southern Yellow Pine are knots, knotholes, splits (either from seasoning, ring hearts or rough handling), shake, wane, red heart, pith, rot, rotten streaks, dote, red heart, wormholes, pitch streaks, pitch pockets, torn grain, loosened grain, seasoning or kiln checks and sap, sap stains and imperfect manufacture.

KNOTS.

4. Knots shall be classified as pin, standard and large, as to size; and round and spike, as to form; and as sound, loose, encased, pith and rotten, as to quality.

5. A pin knot is sound and not over ½ inch in diameter.

6. A standard knot is sound and not over 1½ inches in diameter.

7. A large knot is one any size over 1½ inches in diameter.

8. A round knot is oval or circular in form.

9. A spike knot is one sawn in a lengthwise direction.

The mean or average diameter of knots shall be considered in applying and construing these rules.

10. A sound knot is one solid across its face; is as hard as the wood it is in and is so fixed by growth or position that it will retain its place in the piece.

11. A loose knot is one not held firmly in place by growth or position.

12. A pith knot is a sound knot with a pithhole not more than ¼ inch in diameter.

13. An encased knot is one surrounded wholly or in part by bark or pitch. Where the encasement is less than ⅛ of an inch in width on both sides, not exceeding one-half the circumference of the knot, it shall be considered a sound knot. (See Sections 10 and 17.)

14. A rotten knot is one not as hard as the wood it is in.

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EXHIBIT B — SOUTHERN YELLOW PINE.

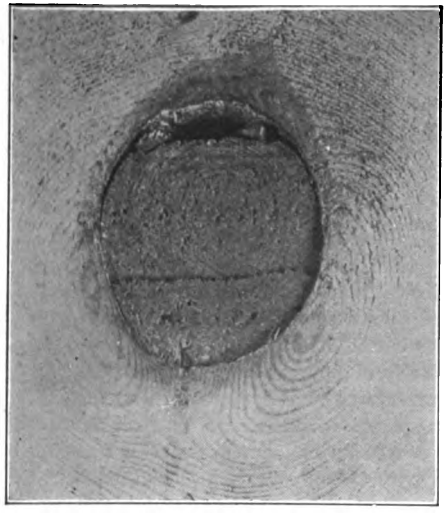


FIG. 1.— LOOSE KNOT.

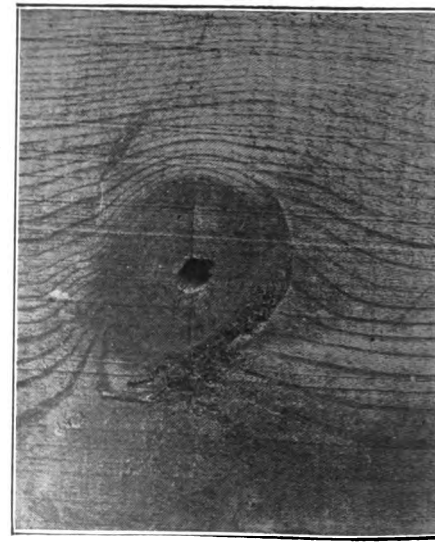


FIG. 2.— PITH KNOT.

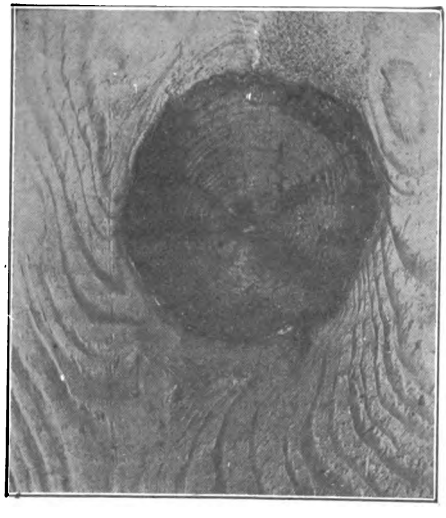


FIG. 3.— ENCASED KNOT.



FIG. 4.— ROTTEN KNOT.

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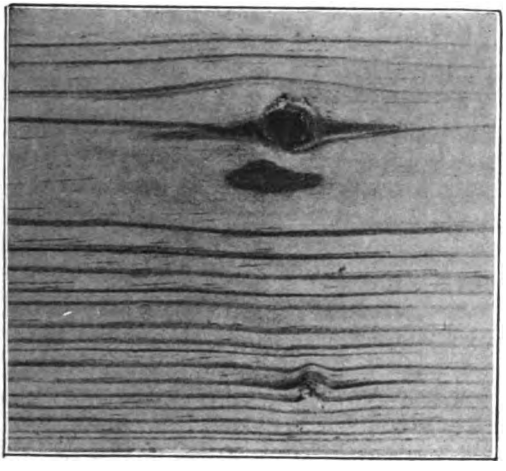


FIG. 5.— PIN KNOT.

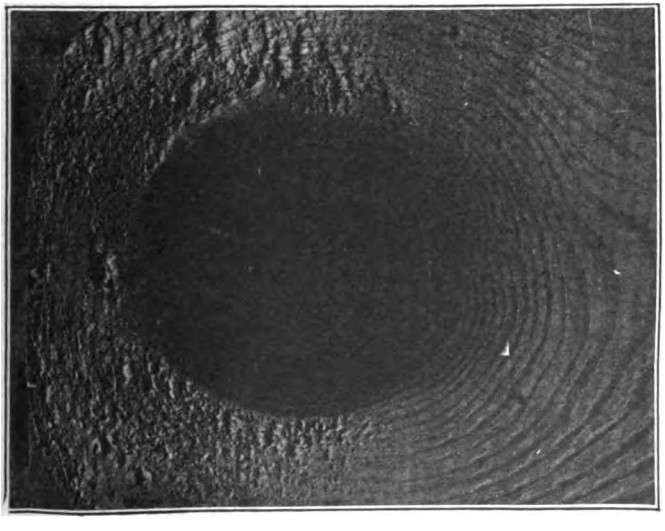


FIG. 6.— STANDARD KNOT.

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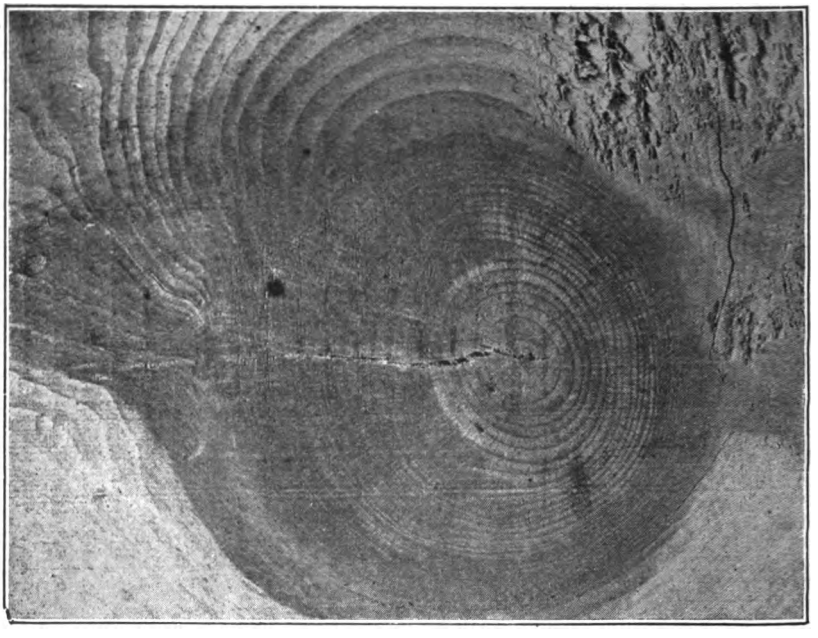


FIG. 7.— LARGE KNOT.



FIG. 8.— SPIKE KNOT.

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PITCH.

15. Pitch pockets are openings between the grain of the wood containing more or less pitch or bark, and shall be classified as small, standard and large pitch pockets.

16. A small pitch pocket is one not over ⅛ of an inch wide.

A standard pitch pocket is one not over ⅜ of an inch wide or 3 inches in length.

A large pitch pocket is one over ⅜ of an inch wide or over 3 inches in length.

17. A pitch pocket showing open on both sides of the piece ⅛ of an inch or more in width shall be considered the same as a knothole.

18. A pitch streak is a well-defined accumulation of pitch at one point in the piece, and when not sufficient to develop a well-defined streak, or where fibre between grains is not saturated with pitch, it shall not be considered a defect.

19. A small pitch streak shall be equivalent to not over one-twelfth the width and one-sixth the length of the piece it is in.

A standard pitch streak shall be equivalent to not over one-sixth the width and one-third of the length of the piece it is in.

(See Exhibit C.)

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EXHIBIT C.



FIG. 9.— PITCH POCKET.

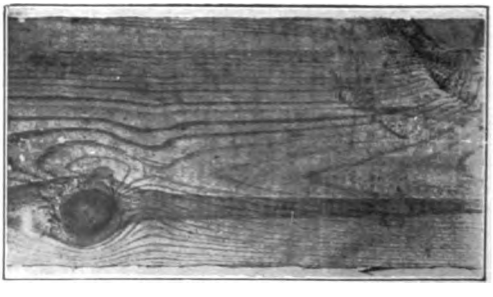


FIG. 10.— PITCH STREAK.

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WANE.

20. Wane is bark, or the lack of wood, from any cause, on the edge.

SAP.

21. Bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

SHAKE.

22. Shakes are splits or checks in timbers which usually cause a separation of the wood between annual rings.

Through Shake: A shake which extends between two faces of a timber.

Ring Shake: An opening between the annual rings.

MISCELLANEOUS.

23. Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

24. All stock except car sills and framing shall be inspected on the face side to determine the grade. Stock surfaced one side, the dressed surface shall be considered the face side. Stock rough or dressed two sides, the best side shall be considered the face, but the reverse side of all such stock shall not be more than one grade lower.

25. Pieces of siding, lining or roofing with 3-16 of an inch or more of tongue will be admitted in any grade, provided it does not run more than one-third the length of the piece.

26. In all grades lower than B and better, wane on the reverse side, not exceeding one-third the width and one-sixth the length of any piece is admissible; provided the wane does not extend into the tongue, or over one-half the thickness below the groove.

27. Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of the cut, and as usually found shall not be classed as torn grain and shall not be considered a defect.

28. Torn grain consists in a part of the wood being torn out in dressing. It occurs around knots and curly places, and is of four distinct characters — slight, medium, heavy and deep.

Slightly torn grain shall not exceed 1-32 of an inch in depth; medium, 1-16 of an inch; heavy, ⅛ of an inch; any torn grain heavier than ⅛ of an inch shall be termed deep.

29. Loosened grain consists in a point of one grain being torn loose from the next grain. It occurs on the heart side of the piece and is a serious defect, especially in flooring.

30. *Rot, Dote and Red Heart:* Any form of decay which may be evident either as a dark-red discoloration not found in the sound wood, or the presence of white or red rotten spots, shall be considered as a defect.

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Firm red heart shall not be considered a defect in any of the grades of Common Lumber.

31. The grade of all regular stock shall be determined by the number, character and position of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the *coarsest* pieces *such grades may contain,* but the average quality of the grade shall be midway between the highest and lowest pieces allowed in the grade.

32. Lumber and timber sawed for specific purposes must be inspected with a view to its adaptability for the use intended.

33. *All dressed stock shall be measured strip count, viz.: Full size of rough material necessarily used in its manufacture.*

34. Equivalent means equal, and in construing and applying these rules, the defects, whether specified or not, are understood to be equivalent in damaging effect to those mentioned applying to stock under consideration.

35. Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or millwork will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

36. The foregoing general observations shall apply to and govern the application of the following rules:

37. *B and Better Car Siding, Lining and Roofing* will admit any two of the following, or their equivalent of combined defects: Sap stain not to exceed five per cent; firm red heart not to exceed fifteen per cent of the face; three pin knots; one standard knot; three small pitch pockets; one standard pitch pocket; one standard pitch streak; slight torn grain, or small kiln or season checks. Where no other defects are contained, six small pin wormholes will be admitted.

38. *Select Car Siding* will admit of one standard pitch streak, one standard pitch pocket, or their equivalent; and, in addition, will admit of not exceeding five pin knots and two standard knots, or their equivalent; ten per cent sap stain; firm red heart; slight shake; heavy torn grain; defects in manufacture or seasoning checks. Pieces otherwise good enough for B, but containing a limited number of pin wormholes shall be graded *select.* This grade is intended to be accumulated from running B and Better stock, and will consist of all the droppings which do not contain defects in excess of those mentioned in this paragraph.

39. *No. 1 Common Car Siding* will admit of the following defects or their equivalent: Sound knots, not over one-half of cross section of the piece at any point throughout its width; three pin knots or their equivalent; wane ½ inch deep on edge not exceeding 1½ inches wide and one-half the length of the piece; torn grain; pitch pockets; pitch; sap stain; seasoning checks; slight shakes; firm red heart and a limited number of small wormholes well scattered. This grade is intended to be worked from fencing stock, either kiln or air dried.

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40. *Select Car Lining and Roofing* will admit of one standard pitch streak; one standard pitch pocket, or their equivalent, and, in addition, sound knots not over one-half the width of the piece in the rough; ten per cent sap stain; firm red heart; slight shakes; heavy torn grain; defects in manufacture, or seasoning checks. Pieces otherwise good enough for B, but containing a limited number of pin wormholes shall be graded *select.* This grade is intended to be accumulated from running B and Better stock, and will consist of all the droppings which do not contain defects in excess of those mentioned in this paragraph.

41. *No. 1 Common Car Lining and Roofing* will admit of the following defects or their equivalent: Sound knots not over one-half the cross section of the piece at any point throughout its length; three pin knots or their equivalent; torn grain; pitch pockets; sap stains; seasoning checks; firm red heart, and a limited number of pin or small wormholes well scattered. This grade is intended to be worked from fencing stock, either kiln or air dried.

42. *Standard Patterns.* (Insert B/P reference, showing net sizes after working.)

43. *All-heart Car Decking or Flooring* will admit sound knots not over one-third of the cross section of the piece at any point throughout its length, provided they are not in groups; pitch pockets; firm red heart; shake and seasoning checks which do not go through the piece; loose or heavy torn grain, or other machine defects, which will lay without waste or will not cause a leakage in cars when loaded with grain. Must be strictly *all heart* on both sides and both edges.

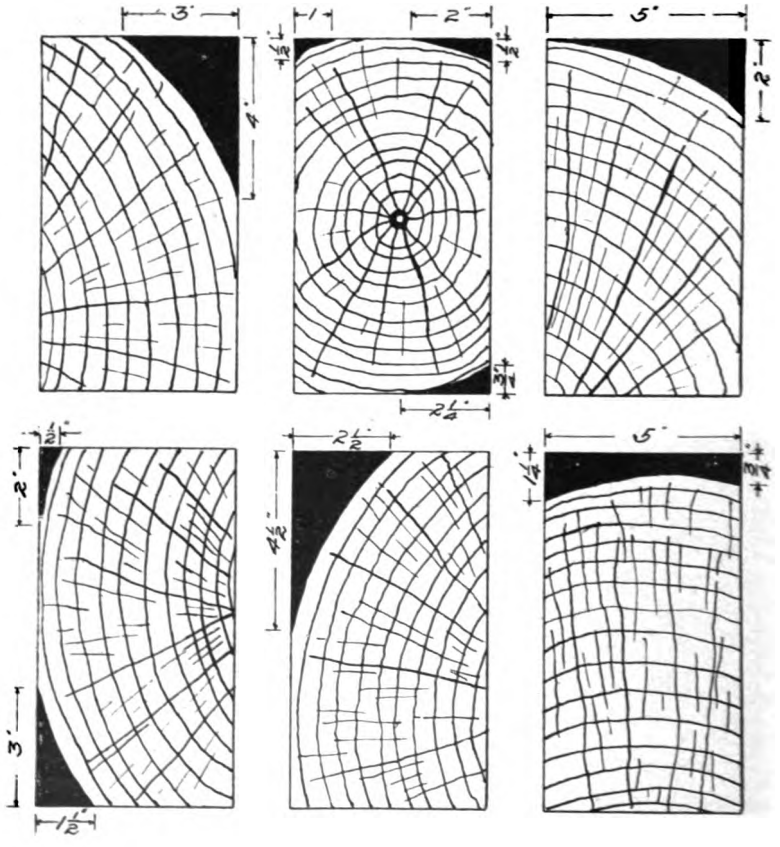
44. *Heart Face Car Decking or Flooring* will admit of sound knots not over one-third the cross section of the piece at any point throughout its length; provided they are not in groups; pitch pockets; firm red heart; shake and seasoning checks which do not go through the piece; loosened or heavy torn grain, or other machine defects, which will lay without waste, or will not cause a leakage in cars when loaded with grain. Will admit of any amount of sap provided all of the face side of the piece is strictly all heart.

45. *No. 1 Common Car Decking or Flooring* will admit of sound knots not over one-half the cross section of the piece at any point throughout its length, provided they are not in groups; pitch pockets; sap stain; firm red heart; shake and seasoning checks which do not go through the piece; a limited number of pin wormholes; loosened or heavy torn grain, or other machine defects, which lay without waste, or will not cause a leakage in cars when loaded with grain.

46. STANDARD LENGTHS:

CAR SIDING — 8, 9, 10 and 12 feet or multiples.
CAR LINING — 8, 9, 10, 12, 14, 16, 18 and 20 feet or multiples.
CAR ROOFING — 5 feet or multiples.
CAR DECKING OR FLOORING — 9 and 10 feet or multiples.

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LUMBER SECTIONS.
SHOWING 75 % HEART.
ALL SECTIONS 5"x9" TOTAL SURFACE 28"

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All orders shall be shipped in standard lengths, unless otherwise specified, but no lengths of either car siding, lining or roofing shall be shipped, except in the lengths specified or multiples thereof. Those who do not desire stock shipped in multiple lengths should so specify.

CAR SILLS AND FRAMING.

47. *No. 1 Common Heart Car Sills and Framing* will admit of sound knots, provided they are not in groups, the mean or average diameter of which shall not exceed two (2) inches; pitch; pitch pockets; slight shake; seasoning checks, or other defects which will not impair its strength more than the defects aforementioned. Must be sawed from sound timber, free from doty or rotten red heart and true to measurements, or at least the measurements at no point on the sill shall be less than the size required.

Measurement of the girth at any point throughout the length of the piece must show at least 75 per cent heartwood.

Cubical contents shall not be used as basis for obtaining percentage of heartwood under this rule.

48. *No. 1 Common Car Sills and Framing* will admit of sound knots, provided they are not in groups, the mean or average diameter of which shall not exceed two (2) inches; pitch; pitch pockets; slight shake; seasoning checks; sap; sap stain, or other defects which will not impair its strength more than the defects aforementioned. Must be sawed true to measurements and from sound timber free from doty or rotten red heart; must be square cornered, except that one (1) inch of wane on one corner or one-half (½) inch of wane on two corners is admissible.

49. *Sizes* up to 6 inches in width shall measure full when green, and not more than ⅛ inch scant when dry or part dry. Sizes 6 to 12 inches in width shall measure full when green and not more than ¼ inch scant when dry or part dry. Sizes 12 to 16 inches in width shall measure full when green and not more than ⅜ inch scant when dry or part dry. Unless otherwise specified, one-fourth inch shall be allowed for each side which is to be dressed. In pieces 3 by 6 inches and under when ordered in lengths exceeding 30 feet, sound knots shall not exceed one-quarter the width of the face through which they project, and the grain shall not cross sufficiently to impair the strength.

CLASSIFICATION AND GRADING RULES FOR LOCOMOTIVE, FREIGHT AND PASSENGER CAR OAK.

GENERAL INSTRUCTIONS.

Those who are not familiar with the anatomy of the oak tree should, when reading over these rules, take into consideration that the rule describes the poorest piece that goes into the grade and that a large percentage is above the grade described.

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DEFINITION OF OAK FOR CONSTRUCTION PURPOSES.

The term "Construction Oak" means all such products of Oak in which the strength and durability of the timber is the controlling element in its selection and use. The following is a list of products which are recommended for consideration as "Construction Oak":

I.— CONSTRUCTION OAK.

(A) }
(B) } Cover Maintenance of Way Material.
(C) }

(D) *Locomotive Timbers:* Sills; End and Truck Timbers.

(E) *Car Timbers:* Car Framing, including Upper Framing, Car Sills, End and Truck Timbers, Car Decking, Inside Lining.

(F) }
(G) }
(H) }
(I) } Cover Maintenance of Way Material.
(J) }
(K) }
(L) }

II.— STANDARD DEFECTS.

Definition of "Defect."— Fault, Blemish, Mark of Imperfection that will materially injure the strength.

Measurements which refer to the diameter of knots or holes shall be considered as referring to the mean or average diameter.

II.— (A) KNOTS.

(1) *Sound Knot.* A sound knot is one which is solid across its face, and which is as hard as the wood surrounding it; it may be any color and contain checks.

(2) *Loose Knot.* A loose knot is one not firmly held in place by growth or position.

(3) *Pith Knot.* A pith knot is a sound knot with a pith hole not more than ¼ inch in diameter in the center.

(4) *Rotten Knot.* A rotten knot is one that is not sound and not as hard as the wood surrounding it.

(5) *Pin Knot.* A pin knot is a sound knot not over ¾ inch in diameter.

(6) *Standard Knot.* A standard knot is a knot not over 2 inches in diameter.

(7) *Large Knot.* A large knot is a sound knot more than 2 inches in diameter.

(8) *Round Knot.* A round knot is one which is oval or circular in form.

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(9) *Spike Knot.* A spike knot is one sawn in lengthwise direction. The mean or average width shall be considered in measuring this knot.

(10) *Bird Peck.* Bruises apparently caused by bird pecks during the growth process of the timber. Considered no defect.



FIG. 1.— SOUND KNOT.

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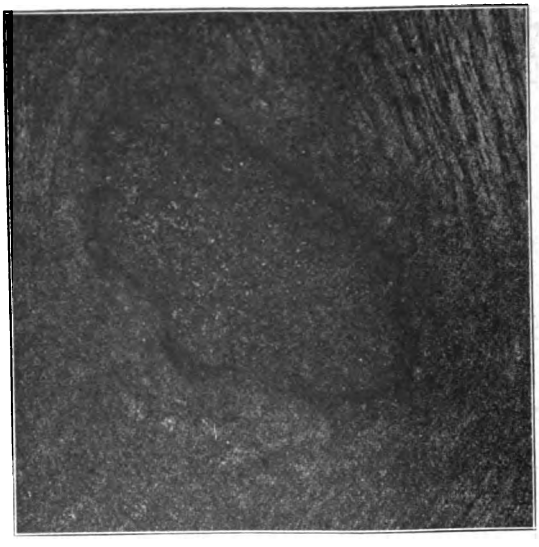


FIG. 2.— LOOSE KNOT.



FIG. 3.— PITH KNOT.

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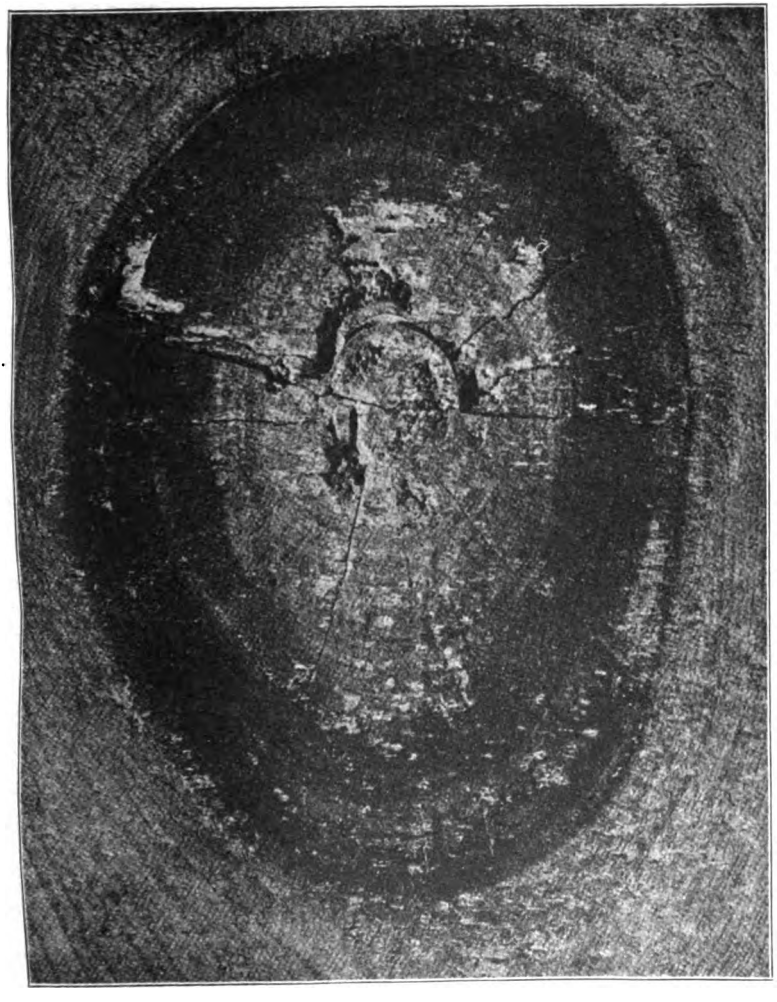


FIG. 4.— ROTTEN KNOT.

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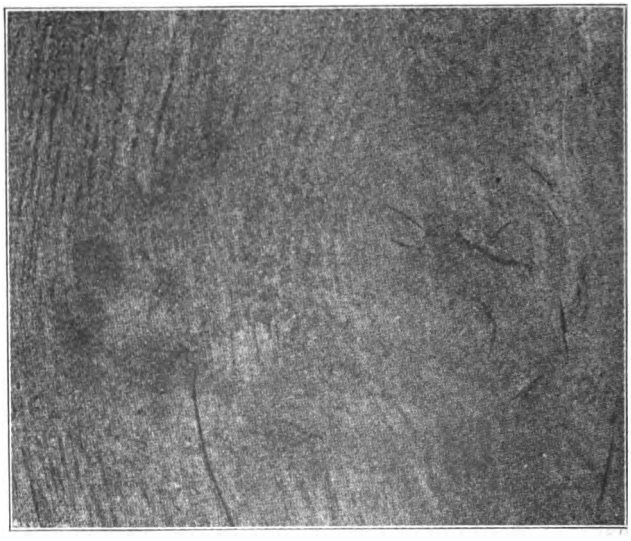


FIG. 5.— PIN KNOT.

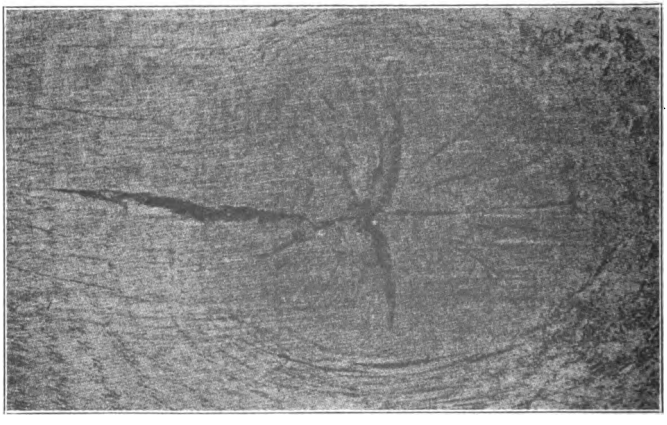


FIG. 6.— STANDARD KNOT.

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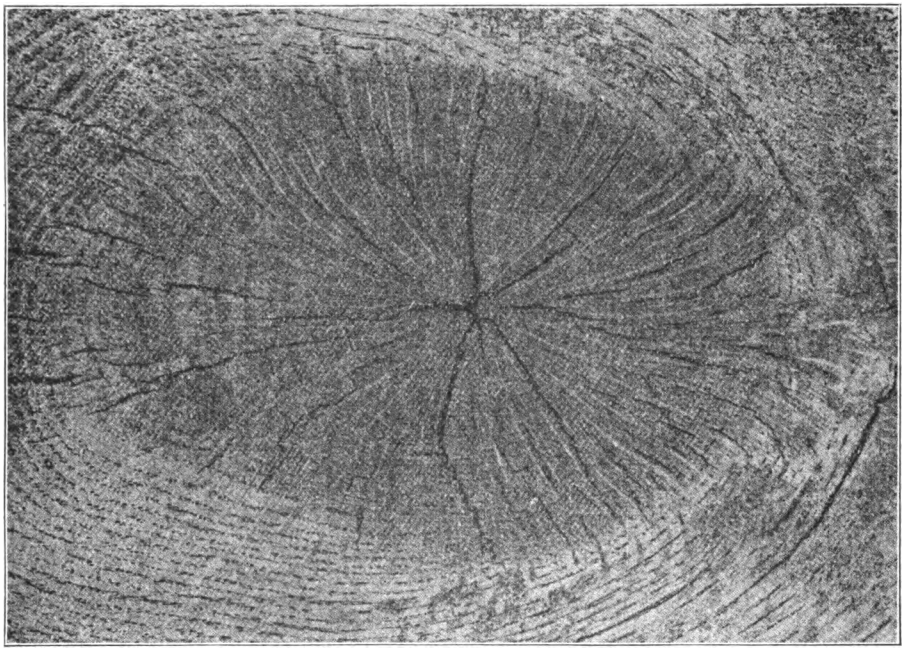


FIG. 7.— LARGE KNOT.

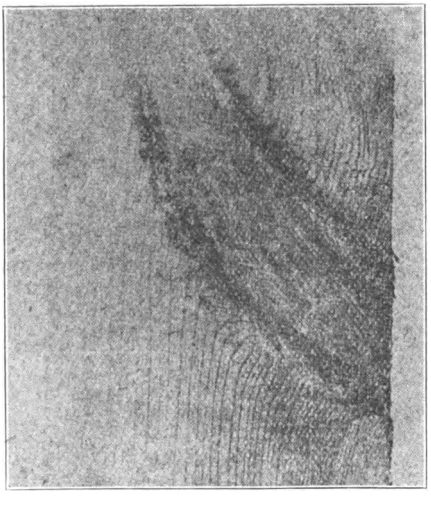


FIG. 8.— SPIKE KNOT.

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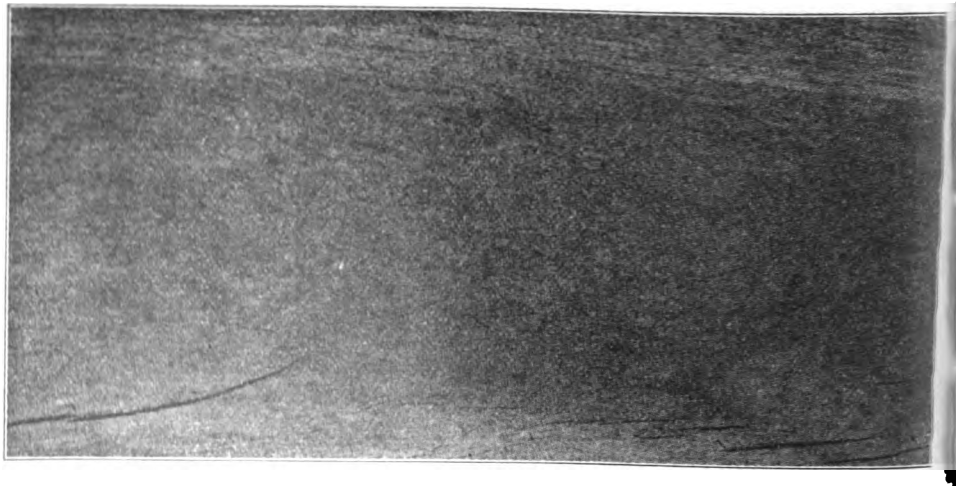


FIG. 9.— BURL KNOT.

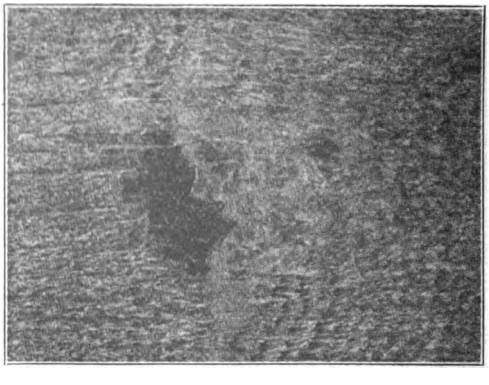


FIG. 10.— BIRD PECK.

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II.— (B) Worm Defects.

(1) *Pin Wormholes.* Pin wormholes are very small holes caused by minute insects or worms. These holes usually are not over 1-16 inch in diameter, or smaller, and the wood surrounding them is sound and does not show any evidences of the wormhole having any effect on the wood other than the opening.

(2) *Spot Worm Defects.* (Also known as Flag Worm Defects.) Spot worm defects are caused, like pin wormholes, by minute insects or worms working on the timber during its growth. The size of the hole is about the same as pin wormholes, but the surrounding wood shows a colored spot as evidence of the defect. This spot is usually sound and does not affect the strength of the piece.

(3) *Grub Wormholes.* Grub wormholes are usually from about ⅛ to 3-16 inch in width and vary in length from about 3-16 inch to 1 inch, and are caused by grub worms working in the wood.

(4) *Wooden Rafting Pinholes.* This defect sometimes appears on river timber which has been rafted and holes bored in the solid wood for tying the timber, and a solid plug or pin driven in the hole filling it completely. These defects must be treated and considered the same as knot defects. Ordinary metal rafting pin or chain dog hole is considered no defect.

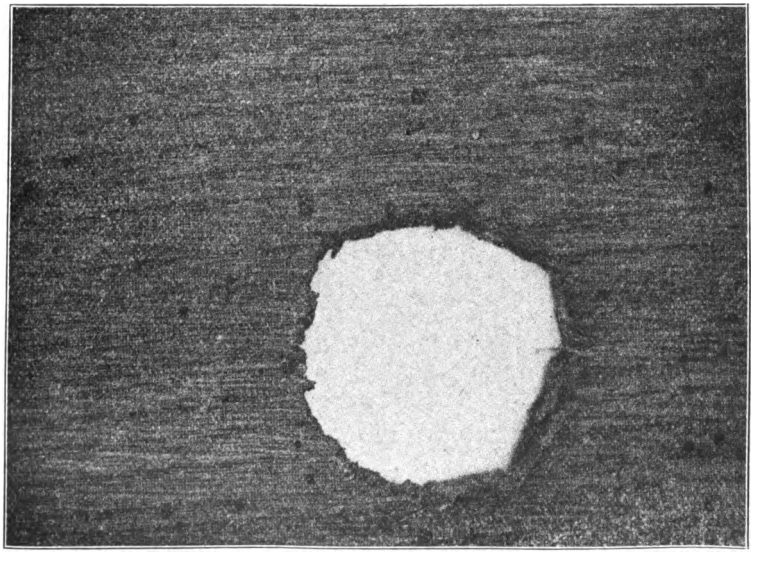


Fig. 1.— Pin Worm Defects

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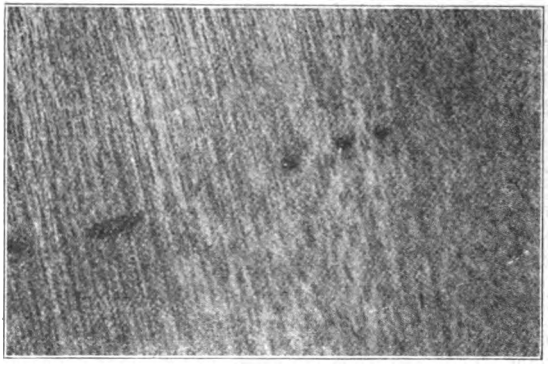


FIG. 2.— SPOT WORM DEFECTS.

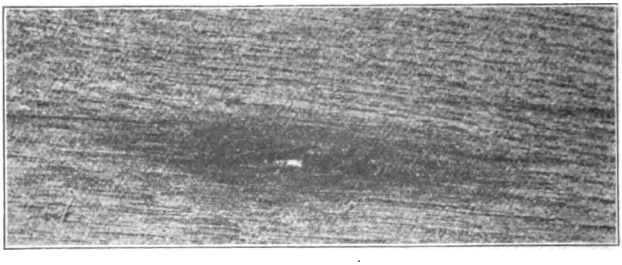


FIG. 3.— METAL RAFTING PINHOLE.



FIG. 4.— GRUB WORMHOLES.

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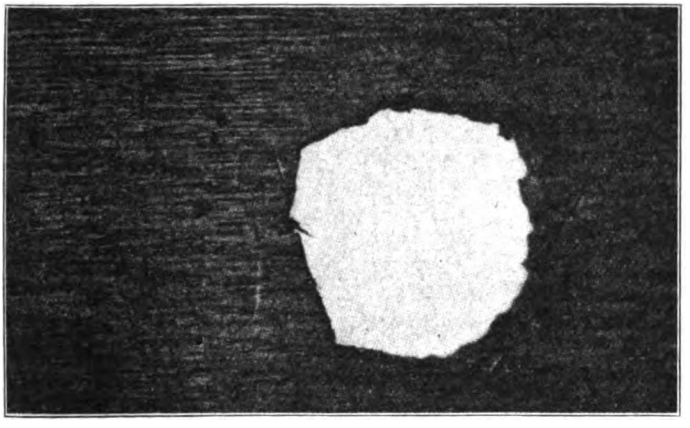


FIG. 5.— WOODEN RAFTING PINHOLES.

II.— (C) SAP.

Definition of "Sap." — The alburnum of a tree — the exterior part of the wood next to the bark; sap wood not considered a defect.

Sound Heart. The term sound heart is used in these rules whenever heart of piece is split or opened and shows on outside of piece and its condition is sound and solid, not decayed. Openings between annual rings are checks not considered a defect.

II.—(D) WANE.

Wane is bark or lack of wood from any cause on edges of timber.

II.— (E) SHAKES.

Definition of "Shakes."— Shakes are splits or checks in timber which usually cause a separation of the wood between the annual rings.

(1) *Ring Shakes.* Ring shakes are openings between the annual rings usually showing only on the end of the timber.

(2) *Through Shakes.* Through shakes are shakes which extend between two faces of the timber.

(3) *Checks.* A small crack in the wood due to seasoning; not considered a defect.

II.— (F) GRAIN.

Crooked or Cross Grain. Crooked or cross grain occurs where the grain crosses the piece within a section of 24 inches in running length of the piece. This is only considered a defect in certain smaller sizes of dimension for specific purposes.

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II.— (G) Rot.

Any form of decay which may be detected as giving the timber a doty or rotten texture is a rot defect, including what is commonly known as dry rot. Water stain, or what are sometimes called scalded or burned spots, usually caused by timber lying in the water under certain conditions before it is sawed, and burned spots where the timber is improperly piled green, not considered defects, as they do not affect the strength of the piece.

III.— Standard Names for Construction Oak.

Standard names for Construction Oak timbers; White Oak and Red Oak. Unless specially mentioned, these terms include the following:

White Oak.	*Red Oak.*
White Oak.	Red Oak.
Burr or Mossy Cup Oak.	Pin Oak.
Rock Oak.	Black Oak.
Post or Iron Oak.	Water Oak.
Overcup.	Willow Oak.
Swamp Post Oak.	Spanish Oak.
Live Oak.	Scarlet Oak.
Chestnut or Tan Bark Oak.	Turkey Oak.
Basket or Cow Oak.	Black Jack or Barn Oak.
Yellow or Chinquapin Oak.	Shingle or Laurel Oak.

Term: Mixed Oak means any kind of oak.

IV.— Standard Specifications for Structural Oak Timbers.

(1) *General Requirements.* Except as noted, all structural timbers shall be white oak, to be sound timber and sawed specified sizes; free from ring shakes, crooked grain, rotten knots, large knots in groups, rot, dote and wane in amounts greater than allowed in these specifications.

(2) *Boxed Hearts.* Boxed hearts are permitted in pieces 5 by 5 square and larger. The center of the heart shall be boxed as near the center of the piece as practical, and not to exceed 30 per cent of the pieces can have the center of the heart nearer than 1½ inches from any face; 20 per cent may show one heart face, corner or edge, not to exceed 75 per cent of the length of the piece.

IV.— (3) Wane.

EXPLANATION.

The term 20 per cent of number of pieces or amount shipped refers to each item and size of each car shipped.

(a) Pieces 5 by 5 to 8 by 8 square may show 1 inch wane, side measurement on any two corners or edges, and this wane not to exceed more than 25 per cent of the length of the piece singly, or 50 per cent in

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aggregate. In the absence of wane on all corners excepting one, the one corner may contain wane 50 per cent of the length of the piecé as above described; not to exceed 20 per cent of number of pieces may have this defect.

(b) Pieces over 8 by 8, including 12 by 12, square may show 1½ inches wane, side measurement, edge of any two corners or edges, and this wane not to exceed more than 33⅓ per cent of the length of the piece singly, or 66⅔ per cent in aggregate. In the absence of wane on all corners excepting one, the one corner may contain wane 66⅔ per cent of the length of the piece as above described; not to exceed 20 per cent of number of pieces may have this defect.

(c) Pieces over 12 by 12 square may show 1¾ inches, side measurement, any two corners or edges, and this wane not to extend more than 40 per cent of the length of the piece singly, or 80 per cent in aggregate. In the absence of wane on all corners excepting one, the one corner may contain wane 80 per cent of the length of the piece as above described; not to exceed 20 per cent of number of pieces may have this defect.

(d) In event that pieces have two faces as wide as above described and two faces narrower, the proportion of the amount of wane is admissible.

(e) Pieces 1 inch to 5 inches thick, not exceeding 8 inches wide, are governed by defect specifications above mentioned, with the exception that they shall not contain wane, and not to exceed 20 per cent of pieces 2 inches and thicker may show sound heart on one face; pieces under 2 inches thick must be free of heart. Pieces 8 inches and wider may contain wane as per paragraphs b and d.

(f) Rough sizes of structural timber shall not vary more than ¼ inch scant of specified size. Dressed sizes may be ½ inch scant after dressing.

V.— (B) Locomotive Timber Oak. Passenger Car Dimension Oak. Refrigerator Car Dimension Oak.

Thickness cut to order, widths cut to order, lengths cut to order. Unless otherwise noted, must be cut from white oak. This stock, wherever practical, should be cut outside the heart and must be free of heart shake in pieces under 6 by 6 square. No attempt should be made to box the heart in pieces smaller than 5 by 7, unless heart is very small and tight. When heart is well boxed it must be firm and tight, and the center of the heart must not be nearer than 2 inches from any face. Must be sawed full to sizes with square edges, and cut from sound timber and free from wormholes, with the exception of a few small pin wormholes well scattered, and an occasional spot worm. None of these defects, however, to affect the serviceability of the piece for the purpose intended. Must be free from split, rot or dote, large, loose, rotten or unsound knots, or, in other words, free of all defects affecting the strength and durability of the piece. Sound standard knots well scattered not considered a defect.

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V.— (C) Freight Car Timber.

Freight car dimensions, including all cars other than refrigerator and passenger cars. Sizes cut to order. Unless otherwise ordered, must be sawed from good merchantable white or red oak timber. This stock must be free of rot, shakes and splits, large, loose, rotten or unsound knots, any of which will materially impair the strength and durability of the piece for the purpose intended. This stock is intended to work full size and length without waste for side posts, braces and end sills, end plates, drafting timbers, cross ties, etc., used in the construction of ordinary freight or stock cars. On pieces 3 by 4 inches or equivalent girth measurement and larger (nothing under 2 inches thick), heart check showing on one corner, admitted on twenty per cent of the pieces in each car shipment. Well-boxed, sound hearts admitted in this material in pieces 5 by 6 and larger.

On pieces 3 by 4 to 6 by 6, inclusive, or equivalent girth measurement and larger (nothing under 2 inches thick), in absence of heart defects, wane on one corner, ¾ inch side measurement, admitted on not to exceed twenty per cent of the number of pieces in each car shipment.

Pieces over 6 by 6 square may contain 1 inch wane, side measurement, on one corner, with other conditions same as 3 by 4 to 6 by 6 sizes.

CLASSIFICATION AND GRADING RULES FOR DOUGLAS FIR CAR AND LOCOMOTIVE MATERIAL.

1. The term "Douglas Fir" will cover the timber known likewise as Yellow, Red, Western, Washington, Oregon or Puget Sound Fir or Pine, Norwest and West Coast Fir.

2. *Douglas Fir Lumber* shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, *except where otherwise expressly stipulated between buyer and seller.*

3. Recognized defects in Douglas Fir are knots, knotholes, splits, checks, wane, rot, rotten streaks, wormholes, dog or picaroon holes, pitch seams, shake, pitch pockets, chipped grain, torn grain, loose grain, solid pitch, stained heart, sap stain and imperfect manufacture.

KNOTS.

4. Knots shall be classified as pin, small, standard and large, as to size; round and spike, as to form, and tight, loose and rotten, as to quality.

5. A pin knot is tight and not over ½ inch in diameter.

6. A small knot is tight and not over ¾ inch in diameter.

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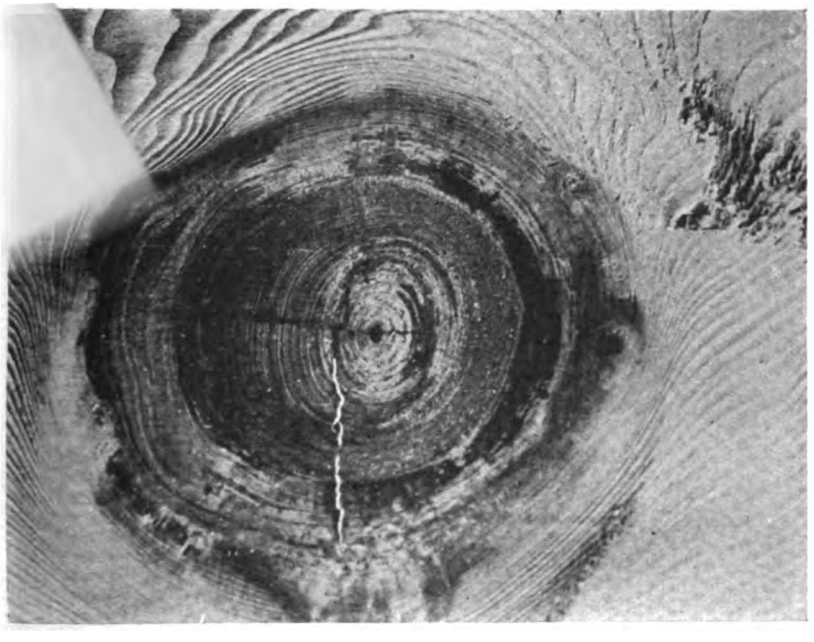


FIG. 4.— LARGE KNOT.

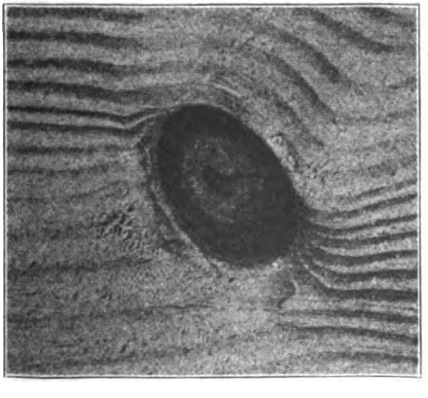


FIG. 5.— SMALL KNOT.

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FIG. 6.— LOOSE KNOT.

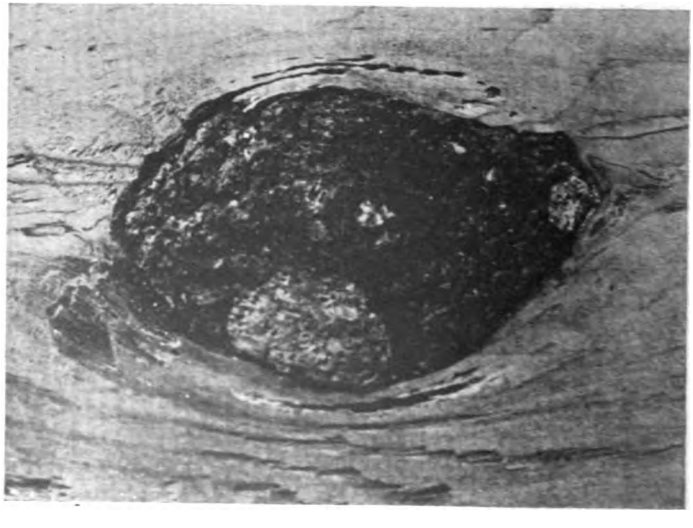


FIG. 7.— ROTTEN KNOT.

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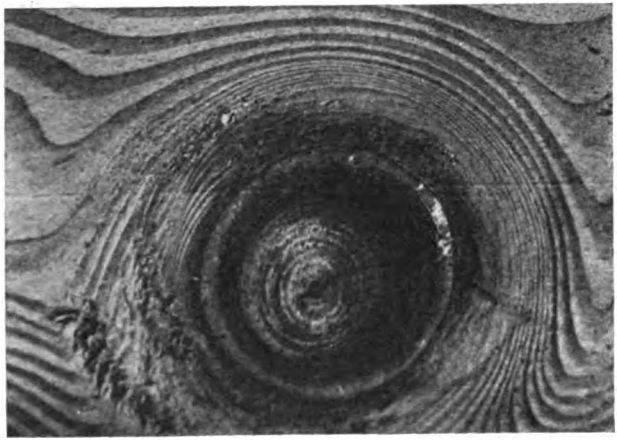


FIG. 8.— PITH KNOT.

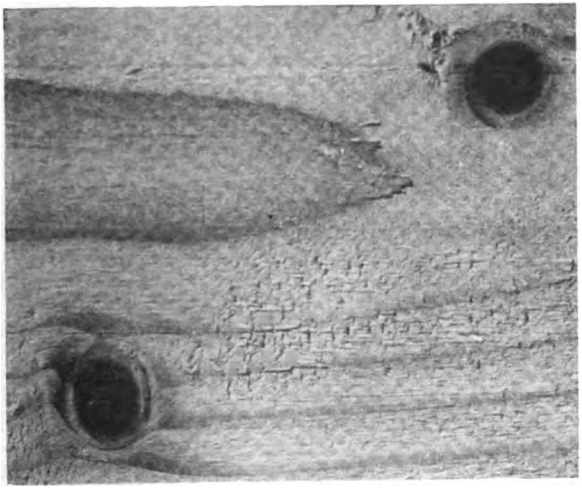


FIG. 9.— PIN KNOT.

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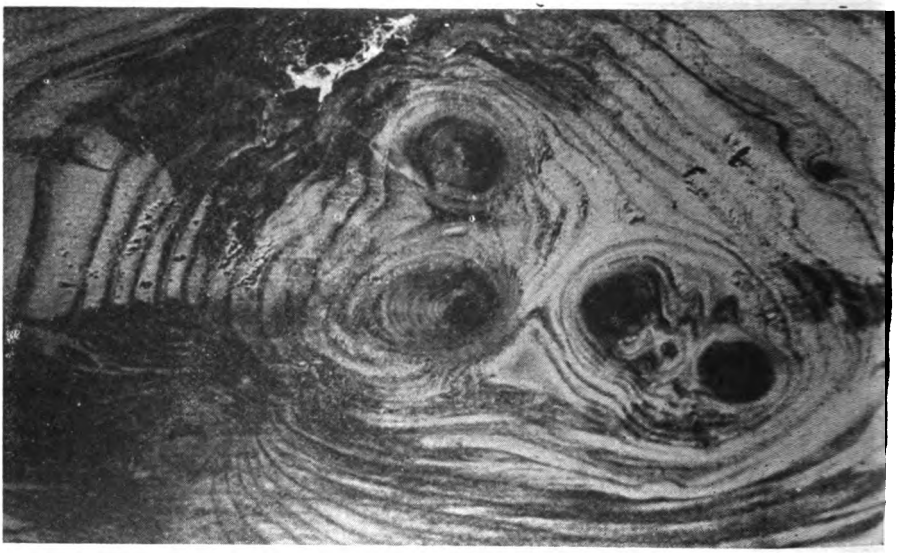


FIG. 10.— CLUSTER OF KNOTS.

PITCH.

14. Pitch pockets are openings between the grain of the wood, containing more or less pitch and surrounded by sound grain wood; they shall be classified as small, standard and large pitch pockets.

15. A small pitch pocket is one not over ⅛ of an inch wide.

16. A standard pitch pocket is one not over ⅜ of an inch wide, or 3 inches in length.

17. A large pitch pocket is one over ⅜ of an inch wide or over 3 inches in length.

18. A pitch shake or seam is a clearly defined opening between the grain of the wood and may be either filled with granulated pitch or not, but in either case is considered a defect in any of the grades hereinafter described.

19. A pitch streak is a well-defined accumulation of pitch at one point in the piece, and when not sufficient to develop a well-defined streak, or where fiber between grains is not saturated with pitch it shall not be considered a defect.

20. A small pitch streak shall be equivalent to not over one-twelfth the width and one-sixth the length of the piece it is in.

21. A standard pitch streak shall be equivalent to not over one-sixth the width and one-third of the length of the piece it is in.

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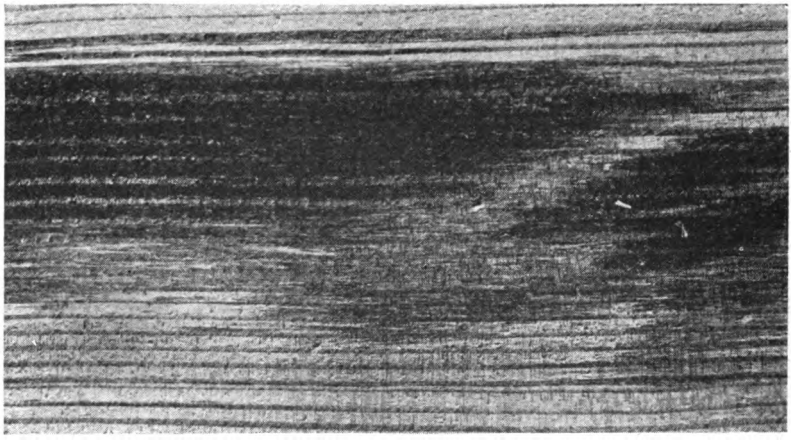


FIG. 1.— SOLID PITCH.

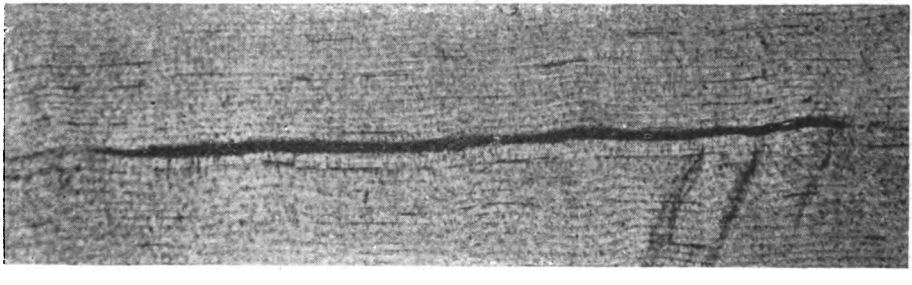


FIG. 2.— LARGE OPEN PITCH POCKET.

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FIG. 3.—SMALL CLOSED PITCH POCKET.

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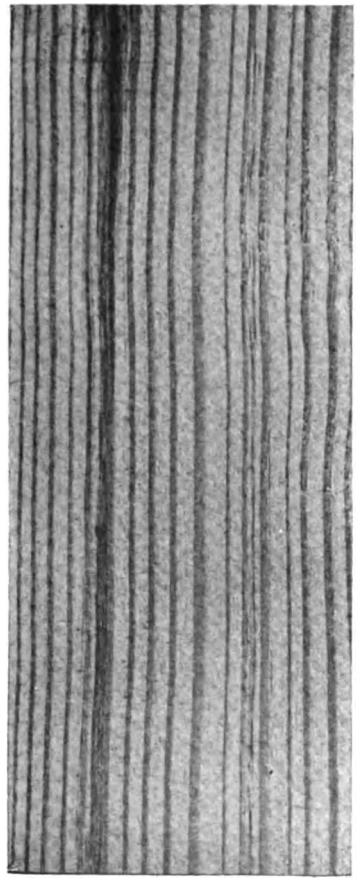


FIG. 4.— SMALL PITCH STREAK.

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WANE.

22. Wane is bark, or the lack of wood, from any cause on edge.

SAP.

23. Bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

24. Sap stain shall not be considered a defect, except as provided herein.

25. Discoloration of the heart of the wood, or stained heart, must not be confounded with rot or rotten streaks. The presence of rot is indicated by decided softness of the wood where it is discolored or by small white spots resembling pin wormholes.

MISCELLANEOUS.

26. Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

27. All stock, except car sills and framing, shall be inspected on the face side to determine the grade. Stock surfaced one side, the dressed surface shall be considered the face side. Stock rough or dressed two sides, the best side shall be considered the face, but the reverse side of all such stock shall not be more than one grade lower.

28. Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of the cut, and as usually found, should not be classed as torn grain, and shall be considered a defect only when it unfits the piece for use intended.

29. Torn grain consists of a part of the wood being torn out in dressing. It occurs around knots and curly places, and is of four distinct characters — slight, medium, heavy and deep.

30. Slight torn grain shall not exceed 1-32 of an inch in depth; medium 1-16 of an inch, and heavy ⅛ of an inch. Any torn grain heavier than ⅛ of an inch shall be termed deep.

31. Loosened grain consists in a point of one grain being torn loose from the next grain. It occurs on the heart side of the piece, and is a serious defect, especially in flooring.

32. The grade of all regular stock shall be determined by the number, character and position of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the *coarsest* piece *such grades may contain,* but the average quality of the grade shall be midway between the highest and lowest pieces allowed in the grade.

33. Lumber and timber sawed for specific purposes must be inspected with a view to its adaptability for the use intended.

34. ***All dressed stock shall be measured strip count, viz.: Full size of rough material necessarily used in its manufacture.***

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35. Equivalent means equal, and in construing and applying these rules, the defects allowed, whether specified or not, are understood to be equivalent in damaging effect to those mentioned applying to stock under consideration.

36. Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or millwork will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

37. The foregoing general observations shall apply to and govern the application of the following rules:

The rules referred to under Sections 38, 39 and 40 govern 4-inch or 6-inch strips, and are intended to cover strips used for car siding, car roofing and car lining.

The term "Edge Grain" is here used an synonymous with vertical grain, rift-sawn, or quarter-sawed. The term "Flat Grain" is synonymous with slash grain or plain sawed.

No. 2 Clear and Better Edge Grain.

38. Material of this grade shall be well manufactured, with angle of grain not less than forty-five degrees. This stock shall be kiln-dried and practically free from all defects, but will admit of bright sap on the face; not exceeding three small close pitch pockets not over 2 inches long, one pin knot, slight roughness in dressing, but not a serious combination of these defects.

No. 2 Clear and Better Flat Grain.

39. Material of this grade shall be well manufactured. The stock shall be kiln-dried and practically free from all defects, but will admit of bright sap on the face; not exceeding three small close pitch pockets not over 2 inches long, one pin knot, slight roughness in dressing, but not a serious combination of these defects.

No. 3 Clear.

40. Material of this grade shall be sound common lumber and will admit of roughness in dressing, bright sap, and also may contain five pin, three small and one standard knot and five pitch pockets in any continuous 5 feet of length of the piece; or any combination of tight knots or pitch pockets equivalent to those mentioned above. This grade particularly refers to stock used for inside lining of freight cars.

Standard Car Decking or Flooring.

41. Material of this grade shall be well manufactured from sound live timber and shall be free from splits, shakes, rot, bark or waney edges, and unsound knots, or pitch pockets, pitch seams or large knots which would weaken the piece for the use intended. This grade will admit of sound knots not to exceed one-third width of the piece, provided they are not in clusters, and sap.

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Common Car Sills and Framing.

42. Material of this grade shall be well manufactured from sound live timber, sawed full size to sizes ordered and free from rot, unsound knots, cross grain, bark or waney edges or shakes, but will admit of sap and any number of sound knots, provided they are not in clusters, and do not exceed one-third width of piece; pitch pockets or pitch seams that would not weaken the piece for the purpose intended.

43. *Sizes* up to 6 inches in width shall measure full when green, and not more than ⅛ inch scant when dry or part dry. Sizes 6 to 12 inches in width shall measure full when green and not more than ¼ inch scant why dry or part dry. Sizes 12 to 16 inches in width shall measure full when green and not more than ⅜ inch scant when dry or part dry. Unless otherwise specified, ¼ inch shall be allowed for each side which is to be dressed. In pieces 3 by 6 inches and under when ordered in lengths exceeding 30 feet, sound knots shall not exceed one-quarter the width of the face through which they project, and the grain shall not cross sufficiently to impair the strength.

44. Standard Lengths.

CAR SIDING — 8, 9, 10 and 12 feet or multiples.

CAR ROOFING — 5 feet or multiples.

CAR LINING — 8, 9, 10, 12, 14, 16, 18 and 20 feet or multiples.

CAR DECKING — 9 and 10 feet or multiples.

All orders shall be shipped in standard lengths, unless otherwise specified, but no lengths of either car siding, lining or roofing shall be shipped, except in the lengths specified or multiples thereof. Those who do not desire stock shipped in multiple lengths should so specify.

CLASSIFICATION AND GRADING RULES FOR CYPRESS CAR MATERIAL.

1. *Cypress* to cover Red, Gulf, Yellow and East Coast Cypress, also known as Bald Cypress.

2. *Cypress Lumber* shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, *except where otherwise expressly stipulated between buyer and seller.*

3. Recognized defects in Cypress are knots, knotholes, sap, wormholes, shake, season checks, splits and wane.

KNOTS.

4. Knots shall be classified as standard and small, as to size, and sound or rotten, as to quality.

5. A standard knot is sound and not to exceed 1¼ inches in diameter.

6. A small knot is one not exceeding ¾ inch in diameter.

7. A sound knot is one solid across its face, is as hard as the wood it is in.

8. A rotten knot is one not as hard as the wood it is in.

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EXHIBIT F — CYPRESS.

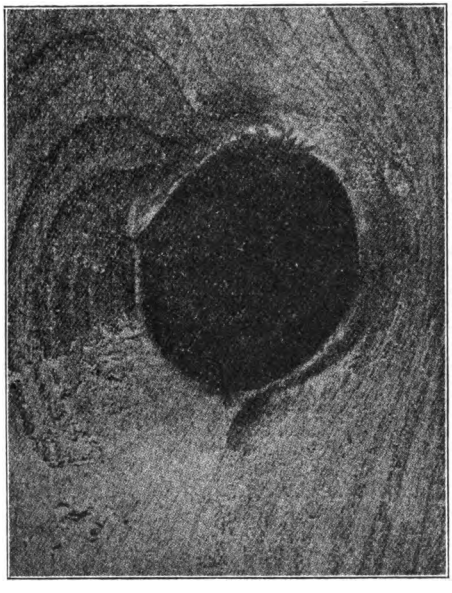


FIG. 1.— STANDARD SOUND KNOT.

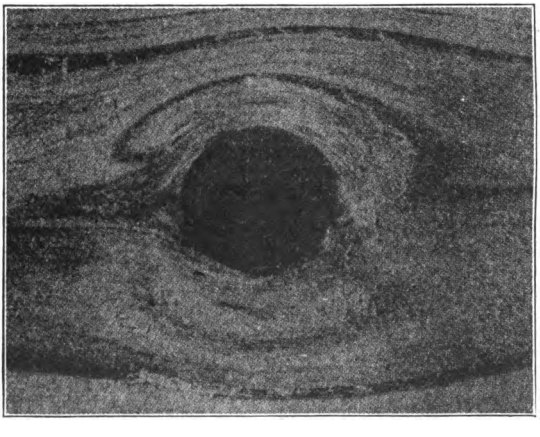


FIG. 2.— SMALL SOUND KNOT.

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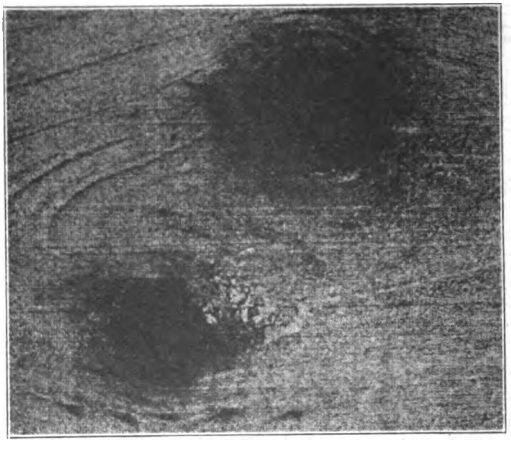


FIG. 3.— TWO SMALL SOUND KNOTS EQUAL TO ONE STANDARD KNOT.



FIG. 4.— ROTTEN KNOT.

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SAP.

9. Stained sap or bright sap shall not be considered a defect in the material specified in these rules.

SEASON CHECKS.

10. Ordinary season checks are such as occur in lumber properly covered on yard or season checks of equal size in kiln-dried lumber.

WANE.

11. Wane is bark or lack of wood from any cause on edge.

MISCELLANEOUS.

12. The grade of all regular stock shall be determined by the number, character and position of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the *coarsest* pieces *such grade may contain,* but the average quality of the grade shall be better than the coarsest pieces allowed in the grade.

13. Lumber sawed for specific purposes must be inspected with a view to its adaptability for the use intended.

14. *All dressed stock shall be measured strip count, viz.: Full size of rough material necessarily used in its manufacture.*

15. Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or millwork will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

16. The foregoing general observations shall apply to and govern the application of the following rule. The rule referred to in the following section is intended to govern 4-inch or 6-inch strips and to cover strips used for car siding, car roofing and car lining.

CAR ROOFING AND SIDING.

"C and Better" Grade.— This grade will admit sound knots, stained sap, pin worm holes, very slight shake and other defects, but none that will prevent the use of each piece in its full width and length for car roofing and car siding; may be random or specified lengths and may be worked to pattern specified and graded from pattern side or S2S and C. M. and graded from the better side.

CAR LINING.

Shall be specified widths and 8 to 20 inches in length. Will admit tight knots, stained sap, pin wormholes, slight shake and other defects, but none that will prevent the use of each piece in its full width and length for car-lining purposes.

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RESOLUTIONS.

Revised and modified at convention, 1903.

At the convention of 1886 the following resolutions prevailed:

Resolved, That this Association deprecates the giving of testimonials or recommendatory letters for publication, and enjoins all to restrict matters of this nature to letters of inquiry. (See page 26, report 1886.)

Resolved, That it is the sense of this convention that in practice it is unnecessary to bead flues in the front end. (See page 152, report 1886.)

At the convention of 1888 the following resolution prevailed:

Resolved, That it is the sense of the Master Mechanics' Association that the pilots of all engines should have steps placed on the front end for the safety and convenience of brakemen while coupling at the front ends. (See page 162, report 1888.)

At the convention of 1893 the following resolution prevailed:

Resolved, That while the Master Mechanics' Association regards the water glass as a convenience and an additional precaution against low water, we do not regard it as an absolute necessity to the safe running of locomotives. (See page 161, report 1893.)

At the convention of 1896 the following resolutions prevailed:

Resolved, That it is the sense of this meeting that the radial stay boiler is as safe as the crown bar boiler, and that the former is easier to keep clean and more economical in repairs. (See page 280, report 1896.)

Resolved, That it is the sense of this Association that the statement of the performance of locomotives should be made on the basis of train load, in lieu of train miles or loaded car miles, as is the prevailing practice at present. (See page 333, report 1896.)

At the convention of 1899 the following resolutions prevailed:

Resolved, That it is the sense of this convention that the time has not arrived when we can abandon instructions to those who use the air brakes, but that the time has arrived when we should perhaps take more care to instruct those who repair the brakes and keep them in order. (See page 71, report 1899.)

Resolved, That it is the sense of the American Railway Master Mechanics' Association that the use of fusible plugs in the crown sheets of locomotive fire boxes is not conducive to the prevention of the overheating of the crown sheet. (See page 153, 1899 report.)

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Resolved, That it is the sense of this Association that the ton-mile basis for motive power statistics is the most practical, and encourages economical methods of operating; and that it is desirable that the heads of motive power departments urge its adoption on their managements. (See page 173, report 1899.)

Resolved, That it is the sense of this Association that it is not advisable to use bars in exhaust nozzles. (See page 277, report 1899.)

At the convention of 1901 the following resolutions prevailed:

Resolved, That it is the sense of this Association that a strict comparison of motive power statistics, one road with another, will not secure the best results, but that such comparisons should be made with the records of the same division for preceding periods of time. (See page 79, report 1901.) (See modification, page 70, 1902 report.)

Resolved, That it is the sense of this Association that the ton-mileage of the locomotive is a just credit to the motive power department for statistical purposes. (See page 83, report 1901.) (See modification, page 77, 1902 report.)

Resolved, That it is the sense of this Association that it is necessary that the side rods should be on engines traveling from the works to the railroad they are built for. (See page 99, report 1901.)

At the convention of 1902 the following resolutions prevailed:

"*Resolved,* That it is the sense of this Association that conclusions based on a comparison of the statistics of one railroad with another may easily prove incorrect, should be given less weight than they usually are, are just only when the accompanying conditions are fairly well known and their influence can be determined with some degree of accuracy; that a comparison of the statistics of a division or a system with those of the same territory for a previous corresponding period very largely eliminates these uncertainties and makes conclusions based on such a comparison much more reliable."

"*Resolved,* That it is the sense of this Association that the ton-mileage of the locomotive and caboose is a just credit to the motive power department for statistical purposes."

"*Resolved,* That the ton-mile is the best practical basis now available for motive power and operating statistics by which to judge the efficiency of locomotive and train service.

"*Resolved,* That actual tonnage should be used in computing ton-mile statistics for comparison with those of other roads, but for comparison with the previous records of the same system or division the use of adjusted tonnage is advisable.

"*Resolved,* That the statistics of passenger, freight, work train and switching services should be on the ton-mile basis, each service in a separate group, and passenger and freight service to be each further grouped under Through and Local.

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"*Resolved,* That the statistics of branch lines and main lines should be kept separately.

"*Resolved,* That the credit of ton-mileage for locomotives in switching service should be proportional to their tractive power.

"*Resolved,* That the ton-mileage of trains using more than one locomotive should be divided among the locomotives attached to these trains in proportion to their tractive power and for the distance over which the helping locomotives are used.

"*Resolved,* That the tonnage of the locomotive should be its weight in working order, plus the light weight of the tender and half its capacity of coal and water."

At the convention of 1906 the following motion was adopted:

That twenty-four hours be adopted as the limit distinguishing between engines in service and those under repairs, and that $100 be adopted as the limit distinguishing between running and shop repairs.

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Obituary.

EDWARD MAURICE ROBERTS.

Mr. Roberts was born in Wales. He came to this country when a boy, with his parents. He died in Ashland, Kentucky, September 6, 1910, of cancer of the throat, after an illness of a year.

He enjoyed the ordinary advantages of education, and early developed the marked mechanical talent which distinguished his business career.

From his youth he was employed with various railroads. He was for many years master mechanic and superintendent of the A. C. & I. R. R., and also superintendent motive power of the East Tennessee, Virginia & Georgia Railroad, located at Atlanta, Georgia; superintendent, South Atlantic Railroad, located at Bristol, Tennessee; superintendent motive power and equipment, Detroit Southern, headquarters Springfield, Ohio; superintendent of the South Carolina Railroad, located at Charleston, South Carolina.

He became a member of this Association in 1883.

The key-note of his character was sterling manhood. He was broad-minded, genial and companionable, making friends wherever he went, and easily infused into them the same ardor and optimism which characterized his personal equipment. Mr. Roberts was a Mason of high degree, being a member of Poage Lodge, of Ashland. He was also a Knight Templar.

Jos. W. Taylor.

DAVID F. VAN RIPER.

David F. Van Riper was born in Meadville, Pennsylvania, on April 18, 1874. His father was a coppersmith in the employ of the Erie Railroad.

Mr. Van Riper's education was secured in the common schools of Meadville. He entered the service of the Erie Railroad as an engine-cleaner, then fifteen years of age. After four years of apprenticeship he

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became a machinist in the Erie shops at Meadville. In January, 1902, he was promoted to the position of foreman of the Erecting Department. A year later he became general foreman over all departments. In 1906 he was transferred to Avon, New York, as master mechanic of the Rochester Division of the Erie Railroad. He held this position until September, 1910, when, owing to ill-health, he resigned and returned to Meadville. On November 28, 1910, he died in the city of his birth.

Mr. Van Riper was a man of kindly disposition. The men employed with him were all his friends. His success in life was due to his ability to handle men and his sound appreciation of the many problems in his branch of the railroad service. His loss is deeply regretted by all who knew him.

Mr. Van Riper became a member of the American Railway Master Mechanics' Association in 1905.

T. RUMNEY.

GEATHER JASON DE VILBISS.

Geather Jason DeVilbiss was born at St. Joseph, Indiana, July 31, 1875, and died September 12, 1910. He began railway work in 1889 as an apprentice on the Wabash Railroad, and was later made roundhouse foreman on the same road at Peru, Indiana. He then went to the Grand Trunk Railway as general foreman of the Battle Creek shops, but was compelled to resign this position on account of ill-health. His next position was roundhouse foreman of the Chicago, Rock Island & Pacific Railway, which he resigned in 1904 to go to the Baltimore & Ohio Railroad as master mechanic. In 1907 has was appointed superintendent of motive power of the Hocking Valley Railway, which position he held at the time of his death.

He became a member of the American Railway Master Mechanics' and of the Master Car Builders' Associations in 1908.

Mr. DeVilbiss was the possessor of a very energetic personality, which immediately impressed itself upon those coming in direct contact with him, resulting in his success as a foreman, master mechanic and superintendent. His charity for all and pleasing disposition gathered about him a host of friends from all walks of life, who were saddened beyond description at his sudden taking from their midst.

He is survived by his widow and one son.

M. A. KINNEY.

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JOHN THOMPSON.

Mr. John Thompson died at his residence, Lakewood Road, Newton Highlands, Massachusetts, February 13, 1911, at eighty-five years, ten months and thirteen days.

Mr. Thompson was one of the pioneers of East Boston, moving there from Marblehead, Massachusetts, where he was born, April 3, 1825. After graduating from school he learned the trade of a machinist, and for many years he was master mechanic of the old Eastern Railroad machine shops in East Boston, and later superintendent motive power of the company. He became a member of the American Railway Master Mechanics' Association in 1869. He was also a life member of the Massachusetts Charitable Mechanics' Association and was formerly a trustee of that institution. He was president of the East Boston Gas Company and vice-president of the East Boston Savings Bank. Mr. Thompson also served the State as a member of the Board of Aldermen, and was in every sense a public-spirited citizen. He leaves a widow, one son and a daughter. Interment was at Forest Hills.

Jos. W. Taylor.

ADAM JOHN DUNN.

Adam John Dunn was born at Galt, Ontario, August 22, 1855. In the spring of 1865 he moved to the States with his father, who located at Woffords Cross Roads, near Cartersville, Georgia. In 1876 Mr. Dunn returned to his native home and entered the foundry and machine shop of Gouldie & McCoulouch, at Galt, with which company he served his apprenticeship. In 1880 he returned to the States and located at Cedartown, Georgia, where he worked in the machine shop of Bob Royer until the spring of 1885, when he went to Knoxville, Tennessee, for the Southern Railway Company, remaining with them fifteen years, finally resigning a position as foreman of the roundhouse to accept a position as master mechanic, in 1900, with the Atlanta, Knoxville & Northern Railroad (now part of the Louisville & Nashville Railroad), headquarters at Blue Ridge, Georgia, at which time he became an active member of the American Railway Master Mechanics' Association and Master Car Builders' Association. When the Atlanta, Knoxville & Northern Railroad was sold by

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Henry K. McHarg to the Louisville & Nashville Railroad, Mr. Dunn accepted a position as master mechanic with the Virginia & Southwestern Railway Company, in 1903, with headquarters in Bristol, Virginia-Tennessee, which position he still held at the time of his death, November 15, 1909.

Mr. Dunn enjoyed the confidence of his employers and of the employees under him. His mechanical ability was of a high order, and he conscientiously discharged any duty assigned him. He was a man of honest, upright and generous character, and won the regard of all who knew him.

R. G. Cox.

WILLIAM C. ENNIS.

William C. Ennis was born in New Jersey in 1845, and died in Paterson, New Jersey, after long illness, October 29, 1910. He was the son of James Ennis and Eliza Hopper.

Mr. Ennis commenced his mechanical career as an apprentice in the old Danforth Locomotive Works and was afterward employed on various railroads until the New Jersey Midland was constructed, when he became its master mechanic. He retained this position on the Midland and its successor, the New York, Susquehanna & Western Railway Company, for twenty-five years, until the latter passed into the hands of the Erie Railroad Company. Later he became master mechanic for the Central New England and Delaware & Hudson Railroads, and served with the American Locomotive Company in different capacities. Mr. Ennis was a trustee of the Methodist Episcopal Church in his home city; was past master of Falls City Lodge, No. 82, F. and A. M.; was a member of the New York Railroad Club, and an honorary member of the American Railway Master Mechanics' Association.

Besides his widow and one daughter, Mr. Ennis leaves five sons, all engaged in railroad or engineering work. The deceased was a man of genial habits, no less agreeable as a companion than conscientious and efficient in his work. He was held in high esteem by his fellows in all ranks of life, and is mourned by friends not only in official railway circles, but among the men in subordinate ranks who for many years served under and admired him.

J. H. Manning.

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DAVID BROWN.

David Brown, assistant superintendent of motive power and equipment of the Delaware, Lackawanna & Western Railway, and who for forty-one years was connected with the mechanical department of this road, died of pneumonia, April 2, 1911, at his home in Scranton, Pennsylvania.

Mr. Brown was born in Canada, May 17, 1838, and commenced railway work in 1851 on the Monmouthshire Railway & Canal Company, at Newport, Monmouthshire, England. He emigrated to the United States in 1870, and went to work the same year as a machinist in the Lackawanna railroad shops, at Scranton, Pennsylvania, where, with one or two changes, he moved slowly upward until he reached the position occupied at the time of his death. He was one of the best purely practical railway mechanical officials on this continent. At the conventions of the American Railway Master Mechanics' Association, which he joined in 1892, Mr. Brown was a ready speaker, noted for the wide range of subjects which he discussed.

In 1898 a new type of consolidation was built in the Lackawanna shops at Scranton, to conform to Mr. Brown's ideas of what a heavy freight locomotive should be, and the engine proved so successful that the form was made a standard by the company. As a shop manager, Mr. Brown had few equals, and although a strict disciplinarian, he continued to be highly popular with those under his supervision.

Mr. Brown was a very kind and generous man, of high character and lofty purpose, wise in counsel, fearless in action, and, until the end, possessing keen intelligence, splendid judgment and rare ability. He was noted for his loyalty, as well as devotion to duty, and, owing to his strong sense of justice, occupied a place in the hearts of men only reached by a few railway officials.

Mr. Brown was a prominent Mason, being a Knight Templar and Shriner. He was also for several years captain of Uniform Rank, No. 60, Knights of Pythias.

ANGUS SINCLAIR.

HENRY S. BRYAN.

Born September 7, 1836, at Cazenovia, Madison County, New York; was educated at G. W. Seminary, Lima, Livingston County, N. Y., and O. C. Seminary, Cazenovia, New York.

Mr. Bryan entered railway service March, 1859, as machinist on the

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Chicago, Burlington & Quincy Railroad, at Aurora, Illinois, until April, 1863, and since which time he has been employed consecutively as follows:

April to December, 1863, machinist, Chicago, Milwaukee & St. Paul Railway shops, Milwaukee, Wis.

December, 1863, to September, 1865, foreman machine shops, Galena Division, Chicago & North Western Railway, at Chicago, Illinois.

October, 1865, to May 1866, machinist, Chicago, Rock Island & Pacific Railway, at Chicago, Illinois.

February, 1866, to February, 1867, machinist, Pittsburgh, Ft. Wayne & Chicago Railway, at Chicago, Illinois.

July, 1867, to May, 1872, machinist and foreman of roundhouse, Lake Shore & Michigan Southern Railway, at Chicago, Illinois.

May, 1872, to May, 1886, master mechanic, Chicago & Iowa Railroad, at Aurora, Illinois. During the years, April, 1873, to April, 1876, was general master mechanic, Chicago & Iowa, Chicago & Pekin, and Chicago, Pekin & South Western Railroads, at the same time.

From January to May, 1886, general master mechanic, Chicago & Iowa and Chicago, Burlington & Northern Railroads, and from May, 1886, to November, 1888, superintendent motive power, Chicago, Burlington & Northern, La Crosse, Wisconsin.

From April, 1889, to September, 1889, business firm of Bryan, Elmer & Sloan, and from September, 1889, to April, 1890, firm of Bryan & Elmer, railway material and supplies, St. Paul, Minnesota.

From April, 1890, to January, 1904, master mechanic, Duluth & Iron Range Railroad, and from January, 1904, to October 2, 1910, superintendent motive power of same road.

Mr. Bryan died at St. Mary's Hospital, Rochester, Minnesota, October 2, 1910. The cause of his death was carcinoma of the colon. In the fall of 1907 Mr. Bryan's physician discovered that he was suffering from the above-named disease, and in December of that year took Mr. Bryan to Rochester, where, on the thirty-first of that month, he underwent an operation. He made an excellent recovery, and it was hoped that he had ridden himself of the disease. The old trouble recurred, however, and in September Mr. Bryan again went to Rochester. He underwent a second operation on Friday, September 23. For a few days after the operation he rallied, and it was hoped that his superb constitution would again win the better of the dread disease. After a few days, however, he grew worse. until the end came as related above.

During the twenty years of his life in Two Harbors he has ever been prominent in the affairs of that city, having served the public in many capacities, being president for three years at the time it was a village.

Mr. Bryan was also prominent in social and fraternal circles, being a member of the Masonic order, Protective Order of Elks and a number of others.

Mr. Bryan had practically given his long life to the service of railways, and had the confidence and respect of all who knew him. He was a

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first-class mechanic in all respects, prominent in the affairs of railway mechanical organizations, and was well and favorably known in all parts of the country for his many good qualities.

J. J. CONOLLY.

GEORGE PARSONS SWEELEY.

Mr. George Parsons Sweeley was born July 13, 1856, died January 10, 1911. He was educated in the common schools. He entered railway service April 1, 1875, as apprentice in the shops of the Pennsylvania Railroad Company, at Renova, Pennsylvania, since which time he has been consecutively, to February 1, 1883, machinist at the same place; to March 1, 1888, foreman, Pittsburgh, Cincinnati, Chicago & St. Louis Railway shops, Indianapolis, Indiana; to March 1, 1893, general foreman, Pittsburgh, Cincinnati, Chicago & St. Louis Railway shops, Columbus, Ohio; to November 1, 1896, master mechanic, Pittsburgh, Fort Wayne & Chicago Railway shops, at Crestline, Ohio; to September 1, 1900, master mechanic, Pittsburgh, Fort Wayne & Chicago Railway shops, at Wellsville, Ohio; to date of death, master mechanic, Pittsburgh, Fort Wayne & Chicago Railway shops, at Pittsburgh, Pennsylvania.

Mr. Sweeley was very genial in his disposition and was beloved by all who knew him. He was just and upright in all his dealings with his fellow men. He won his way in life by his own efforts and merit.

W. C. ARP.

JOHN G. THOMAS.

Mr. John G. Thomas was born at Philadelphia, Pennsylvania, in 1846, and after receiving his education in the public school of that city, he entered the service of the Philadelphia & Reading Railway Company as a machinist apprentice, at their Reading (Pa.) Shops, on the completion of which he was assigned to road service, as locomotive engineer. This position he gave up after a time and went to Virginia, and later to Cuba. Returning to the States, he took up work with the Government in the nature of a contract position of putting up marine engines. This position he resigned to accept service with the Baldwin Locomotive Company, at Philadelphia, Pennsylvania, which position he resigned and returned to the Philadelphia & Reading Railway as a machinist in their Reading Shops, from which position he was later promoted to Superintendent of Shops of the same company. This position he resigned to take up work with the Central Railroad

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Company of New Jersey, as Assistant Superintendent Motive Power, with office at Jersey City, New Jersey, in which capacity he served until April 15, 1893, when he was transferred to Master Mechanic of the Lehigh & Susquehanna Division of the same company, which position he held at the time of his death, which took place in Philadelphia, Pennsylvania, May 26, 1909.

Mr. Thomas was a good mechanic, faithful and loyal in the discharge of his duties, esteemed and respected, and his death was deeply regretted by all.

C. E. CHAMBERS.

JAMES B. GANNON.

James B. Gannon was born March 23, 1859, and died at Trenton, New Jersey, June 19, 1910, from the result of a surgical operation in the Trenton Hospital.

After receiving a common school education he accepted employment with the New York, Susquehanna & Western Railroad Company as fireman, which position he held for six years until promoted to engineer, and after acting in this capacity for a period of two years left the service of the New York, Susquehanna & Western and accepted a similar position with the New York City & Northern Railroad, now a part of the New York Central & Hudson River Railroad; after serving eleven years in this position was placed as engine dispatcher in charge of the shops at Highbridge, New York City, and two years later was transferred to Mott Haven in similar capacity, where he remained for one year and then resigned to accept position as Master Mechanic, Southern Railway, at Louisville, Kentucky. One year later he was transferred to Alexandria, Virginia, as Trainmaster, four years later resigned to accept a Master Mechanicship, Central New England Railway, at Hartford, Connecticut, in which position he remained for two years, when he resigned to take employment with the New York, New Haven & Hartford Railroad as Master Mechanic, and continued in the service of this company until November 1, 1908. On account of ill health, Mr. Gannon did not engage in active work after leaving the service of the New York, New Haven & Hartford Railroad.

He joined the American Railway Master Mechanics' Association in 1904. A widow and two children survive him.

G. W. WILDIN.

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PAST PRESIDENTS

H. M. Britton	1868 to 1876.	Deceased.
N. E. Chapman	1876 " 1880.	Deceased.
J. N. Lauder	1880 " 1882.	Deceased.
Reuben Wells	1882 " 1884.	
John H. Flynn	1884 " 1885.	Deceased.
J. Davis Barnett	1884 " 1885.	Acting President.
J. Davis Barnett	1885 " 1886.	
William Woodcock	1886 " 1887.	Deceased.
Jacob Johann	1886 " 1887.	Acting President.
J. H. Setchel	1887 " 1889.	
R. H. Briggs	1889 " 1890.	
John Mackenzie	1890 " 1892.	
John Hickey	1892 " 1894.	
W. Garstang	1894 " 1895.	
R. C. Blackall	1895 " 1896.	Deceased.
R. H. Soule	1896 " 1897.	
Pulaski Leeds	1897 " 1898.	Deceased.
Robert Quayle	1898 " 1899.	
J. H. McConnell	1899 " 1900.	
W. S. Morris	1900 " 1901.	
A. M. Waitt	1901 " 1902.	
G. W. West	1902 " 1903.	Deceased.
W. H. Lewis	1903 " 1904.	
P. H. Peck	1904 " 1905.	Deceased.
H. F. Ball	1905 " 1906.	
J. F. Deems	1906 " 1907.	
Wm. McIntosh	1907 " 1908.	
H. H. Vaughan	1908 " 1909.	
G. W. Wildin	1909 " 1910.	
C. E. Fuller	1910 " 1911.	

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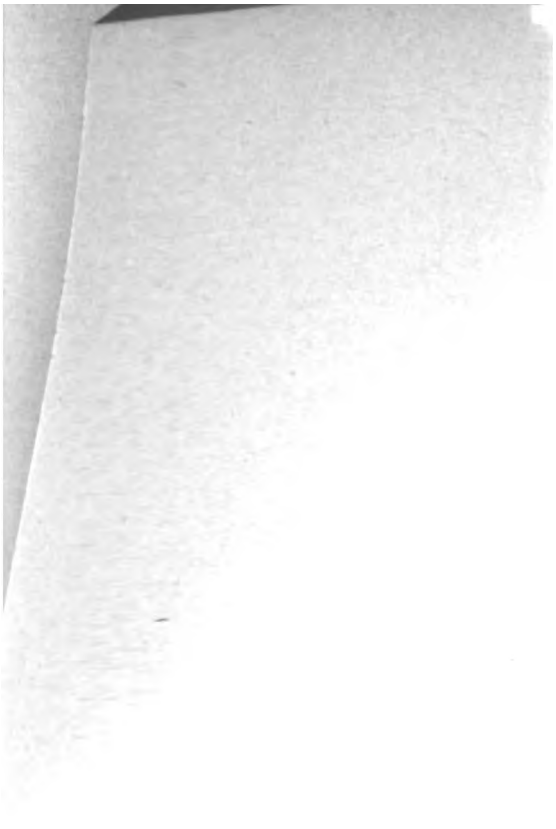
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